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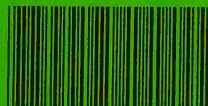


TF 2415

Counter/Timer

INSTRUCTION MANUAL

MP MASTER



MA23662

MARCONI INSTRUMENTS LIMITED

Instruction Manual
No. EB 2415
for
Counter/Timer
TF 2415

SER/No. U.2602.

24/11/1969.

CHANGE OF FREQUENCY UNIT

Marconi Instruments, in accordance with international usage, has decided to adopt the hertz (Hz) as the name of the unit of frequency in place of the cycle per second (c/s). During the transition period the frequency units in this instruction manual may not agree with those on the equipment. The value of the alternative units and that of their multiples - kHz and kc/s, MHz and Mc/s, GHz and Gc/s - is, however, identical.



1968

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

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General information

1.1 INTRODUCTION

This instrument is a versatile six digit counter for the measurement of Frequency and Frequency-ratio, Period measurement (by single period or multi-period sampling) and Time interval measurement: it may also be employed as a general purpose Counter.

The six digit and symbol readout is presented by in-line neon indicator tubes mounted behind a Polaroid display screen for optimum contrast. The display time may be varied and an overflow-output and overflow indication lamp are provided.

The instrument has a memory facility for storing a measurement while another is accumulated: use of this facility is selectable at a two-position switch.

The accuracy of all time-dependent

measurements is determined by the internal reference source which is an oven-controlled 2 MHz high stability crystal oscillator.

Provision is made for the use of an external reference source and test facilities and a standard frequency output (selectable in decade steps from 0.1 Hz to 1 MHz) are incorporated.

Slope and trigger-level are selectable at the Start and Stop inputs. Auxiliary connections are provided at the rear panel and outputs for data logging equipment are available as an optional extra.

Silicon semi-conductor devices are used throughout the instrument which is essentially of plug-in printed circuit design enclosed by a p.v.c. covered dual sectioned case. The unit is fitted with a swivelling carrying handle which may be locked in position to form a tilt stand.



1.2 DATA SUMMARY

Input: Three channels: A, B and C.

Presentation: 6 decade in line readout with automatic decimal point indication and units annunciator.

1.2.1. FREQUENCY FUNCTION

Ranges: A.C. : 10 Hz to 20 MHz.
D.C. : D.C. to 20 MHz.

Accuracy: ± 1 count $\pm$ crystal stability

Signal Specification: (A-input)
A.C. : Sensitivity (sinusoidal signals above 10 Hz) 100 mV r.m.s.
Max. amplitude 250 V r.m.s.
Max. d.c. level of signal 400 V
(N.B. Damage may be caused if the input voltage exceeds 400 V).
D.C. : Max. Amplitude ± 120 V ('peak' if a.c.)
(N.B. Damage may be caused if the input level exceeds 120 V).

Pulse Response: The instrument is triggered by:-
(i) Negative pulses of amplitude 100 mV min.
(ii) Positive pulses: amplitude dependent upon pulse rise time, 1 V min for rise times not greater than 10 ns per volt.

Maximum Rise time: 50 ms per volt.

Paired-pulse Resolution: Typically better than 0.2 μ s (i.e. with pulse width 0.1 μ s and inter-pulse-spacing 0.1 μ s).

Input Impedance (A.C. & D.C.): 250 k Ω in parallel with 45 pF.

Gating Times (selectable): 0.01, 0.1, 1, 10, 100 seconds.

1.2.2. PERIOD FUNCTION

Ranges: A.C.: 10 Hz to 1 MHz.
D.C. : D.C. to 1 MHz.
Below 10 Hz Sensitivity decreases

Signal Specification: As for Frequency measurement

Input Impedance: As for Frequency measurement

Accuracy: As for Frequency measurement $\pm$ Trigger level error
Trigger level error:-
Range '1' : Less than $\pm 0.03\%$ (for sinusoidal inputs of amplitude not less than 1 V r.m.s. and frequency not less than 100 Hz).
Other Ranges : Error decreases by factor of 10 per range (e.g. on Range 10 error:- less than $\pm 0.003\%$).

Accuracy on each range improves rapidly with increase in signal amplitude above 1 V r.m.s. and/or with reduction in input signal rise time.

Gating Times: 1 to 10^6 cycles (in decade steps) of input frequency.

Timing Units: On 'Multi-Period' : 1 μ s
On 'Timing A-A' : 1 μ s to 1 second (selectable in decade steps).

1.2.3. TIMING (Including specification of B & C control signals)

Range: 1 μ s to 999999 seconds

Accuracy: $\pm 1 \mu$ s $\begin{matrix} +0 \\ -1 \end{matrix}$ time unit

Timing Units: 1 μ s to 1 second (selectable in decade steps)

Timing Functions:

- (i) 'A $\rightarrow$ A': Time between two consecutive A-input signals.
Signal specification : as for Frequency measurement. (A-input)
- (ii) 'B $\rightarrow$ C Pulse': Time between B-input pulse (or depression of Start push-button) and C-input pulse (or depression of Stop push-button)
Signal specification : Positive or negative pulse. (d.c.-coupled B & C inputs)
Amplitude: Min. 1 V peak to peak
Max. 50 V peak to peak
Trigger Level: Adjustable between +3 V and -3 V
Input Impedance : min. 10 k Ω

- (iii) 'B. $\bar{C}$ Contact' Time between 'making' of normally-open contacts connected between B-input and chassis-earth (or depression of 'B' push-button) and either:-
- (i) 'breaking' of above contacts (or release of 'B' push-button)
- or (ii) 'making' of normally-open contacts connected between C-input and chassis-earth (or depression of 'C' push-button).

1.2.4 COUNT (A-input)

Count Function $\frac{A}{B \rightarrow C}$:

Signals via A-input counted for time between B-input pulse (or depression of Start push-button) and C-input pulse (or depression of Stop push-button).

1.2.5. INTERNAL REFERENCE SOURCE

2 MHz oven-controlled AT-cut crystal
Oven temperature $70^{\circ} \pm 1^{\circ}\text{C}$ (proportional control)

Frequency Stability:

For ambient temperature variation within range
 -10° to $+60^{\circ}\text{C}$, typically ± 5 parts in 10^8 .

For any constant ambient temperature within range
 -10° to $+60^{\circ}\text{C}$:-

Short term stability: After initial warm-up period of 30 min
 ± 1 part in 10^7

After 2 hours
continuous operation, typically ± 3 parts in 10^8 for any 1-hour period.

Long term stability: After 6 weeks
continuous operation, typically ± 1 part in 10^8 per 24 hours.

After 3 months
continuous operation, typically ± 3 parts in 10^9 per 24 hours.

1.2.6 EXTERNAL (Crystal) REFERENCE INPUT

Frequency:

100 Hz to 3 MHz

Sensitivity:

100 mV r.m.s. up to 1 MHz falling to 250 mV r.m.s. at 3 MHz.

Input Impedance:

10 k Ω

1.2.7 TEST FREQUENCY OUTPUT

Frequency:

1 MHz

Amplitude:

2 V peak (i.e. 0 V to +2 V)

Waveform:

Square

Output Impedance:

approx. 1 k Ω

1.2.8 DISPLAY TIME

Memory - OFF: Adjustable between approx. 0.5 and 5 seconds. With Display time setting 'Infinity', the readout is retained until the Reset push-button is momentarily depressed (reset action may also be triggered remotely).

Memory - ON: The readout shown is the result held in the memory store. Operation of the Display timer circuit, or the Reset push-button, resets the main counter, but the stored result remains displayed until, upon gate-closure at the end of a new gating period, the readout changes to show a new result.

1.2.9 AUXILIARY INPUTS/OUTPUTS

a) Start InputOpen circuit level: $-0.7 \text{ V} \pm 0.1 \text{ V}$ (with respect to earth)Input Impedance: $47 \text{ k}\Omega$ in parallel with 22 pF b) Reset InputOpen circuit level: $+6 \text{ V} \pm 0.1 \text{ V}$ (with respect to earth)Input Impedance: $1 \text{ k}\Omega$ c) Divider Output (Standard
Frequency Output)

Frequency: 0.1 Hz to 1 MHz selectable in decade steps.
Output frequency dependent upon selected function
viz:-

(1) Function Selector set to 'Frequency'Output frequency dependent upon range setting
at function selector:-(a) With Internal Reference or 1 MHz
External Reference:-Frequency selectable in decade steps
from 0.01 Hz (setting '100s') to 100 Hz
(setting '0.01s').

(b) With External Reference used:-

Output frequency is External Reference
frequency divided by 10^8 (setting '100s')
'100s') to 10^4 (setting '0.01s').(2) Function Selector set to 'Timing'Output frequency dependent upon setting of
Period Cycles/Time Units switch (black fig-
ures):-

(i) With Internal Reference used:-

Frequency selectable in decade steps
from 1 Hz (setting ' 10^6 ') to 1 MHz
(setting '1').

(ii) With External Reference used:-

Output frequency is External Reference
frequency divided by Period Cycles/
Timing Units switch setting (i.e. 1 to
 10^6 selectable in decade steps).Signal Amplitude: 2 V peak-to-peak $\pm 0.2 \text{ V}$

Waveform: Rectangular

Mark to Space Ratio: $1:1$ for 1 MHz ; other frequencies $1:4$ Mark level $+2 \text{ V} \pm 0.3 \text{ V}$ Space level $0 \text{ V} \pm 0.2 \text{ V}$ Output Impedance: $1 \text{ k}\Omega$

d) ±6 V Outputs

These outputs are available to power ancillary circuits.

Maximum load current:-

+6 V supply : 20 mA

-6 V supply : 10 mA

e) Carry Pulse Output
(from counter)

Signal: Positive pulse (swing approx. +0.5 V to +5 V)
Leading-edge coincident with count 800000
Trailing-edge (Carry Signal) coincident with count 1000000

Output Impedance: Approx. 600Ω

f) Overflow Output
(from store)

For Memory OFF: Overflow signal occurs coincident with the trailing edge of the Carry Pulse.

For Memory ON: When the count capacity has been exceeded an Overflow signal occurs coincident with the production of the next Memory Transfer pulse.

Signal: d.c. level change from +0.5 V to +5 V (approx.)

Rise Time: approximately 100 ns

Pulse Width: On Memory - OFF, trailing-edge coincident with reset.
On Memory - ON, trailing-edge coincident with the next Memory Transfer signal but +5 V level is maintained if an overflow indication is required by the new count transferred to the memory store.

Output Impedance: 1 kΩ in parallel with 50 pF

g) Store Transfer Output

Produced only with Memory setting "ON"; it is coincident with the gate closure.

Signal: Positive pulse (swing approx. 0 V to +5 V)

Pulse Width: 5 μs

Min. Load Resistance: 120Ω (to 0 V line)

h) Start-B and Stop-C
Shaper Outputs

Waveform: Rectangular (Mark-space-ratio for sinusoidal input, dependent upon setting of trigger-level control)

Amplitude: 2 V peak (swing 0 V to +2 V)

i) DATA LOGGING FACILITY
(Optional Extra)

4 lines or 8 lines per digit, plus 4 control lines
Code: 1-2-4-8 binary coded decimal

<u>Outputs:</u>	<u>Output Impedance (approx.)</u>	<u>Min. Load Resistance</u>	<u>Open Circuit Levels</u> (approx.)	
			<u>Std.</u>	<u>'Inverted'</u>
			<u>4-Line Output</u> (Socket A)	<u>4-Line Output</u> (Socket B)
Digit Lines:	1 k Ω	10 k Ω	'1' : +3.5 V min.	+0.5 V max.
			'0' : +0.5 V max.	+3.5 V min.

Print Command: 4 k Ω Signal:-
5 V negative-going transition (+5 V to 0 V). On 'Timing B.C. Contact' signal returns to +5 V approx. 1 ms later; on all other functions signal returns to +5 V coincident with reset.

<u>Input:</u>	<u>Open Circuit Level (approx.)</u>	<u>Signal</u>
Inhibit	+6 V	Connect input line to 'earth' for duration of required hold period. Max. load resistance to 0 V line 5 k Ω .

1.2.10 POWER SUPPLY 100 - 125 V, 40 - 60 Hz or
200 - 250 V, 40 - 60 Hz

Consumption: approx. 40 W.

1.2.11 TEMPERATURE RANGE -10^o to +60^o Centigrade

1.2.12 DIMENSIONS AND WEIGHT (Approx.)	<u>Weight - 20 lb (9.1 kg)</u>		
	<u>Case size -</u>	<u>Width</u>	<u>Height</u>
			<u>Depth</u> (front to rear)
		13 $\frac{3}{4}$ in (34.8 cm)	5 $\frac{3}{16}$ in (13.5 cm)
			13 $\frac{1}{8}$ in (33.3 cm)

1.3 ACCESSORIES

1.3.1 ACCESSORIES SUPPLIED 3 - BNC free plugs
2 - Binding post adaptors

1.3.2 OPTIONAL ACCESSORIES 14 way free plug for Auxiliary connector
36 way free plugs for Data Logging output connectors on special versions.

1.4 ACCURACY OF ELECTRONIC COUNTERS

In general there will always be a possible error of ± 1 count on the least significant digit. This, together with the discrimination required, will determine whether Frequency or Period measurement is used.

(1) Frequency Measurement. Accuracy is determined by the stability of the internal standard which provides the accurate counting interval. In addition there will be the ± 1 count and thus for a given gate time higher frequencies will be displayed with the greatest discrimination and accuracy.

(2) Period Measurement. The errors in period measurement will be :- (a) ambiguity of gate triggering level. (b) Accuracy of internal timing units. (c) The ± 1 count.

For sine wave inputs the total possible error may be expressed as

$$\frac{1}{\pi} \times \frac{E_n}{E_s} \quad \text{where}$$

E_n = total noise, including that due to counter circuitry,
 E_s = signal level,

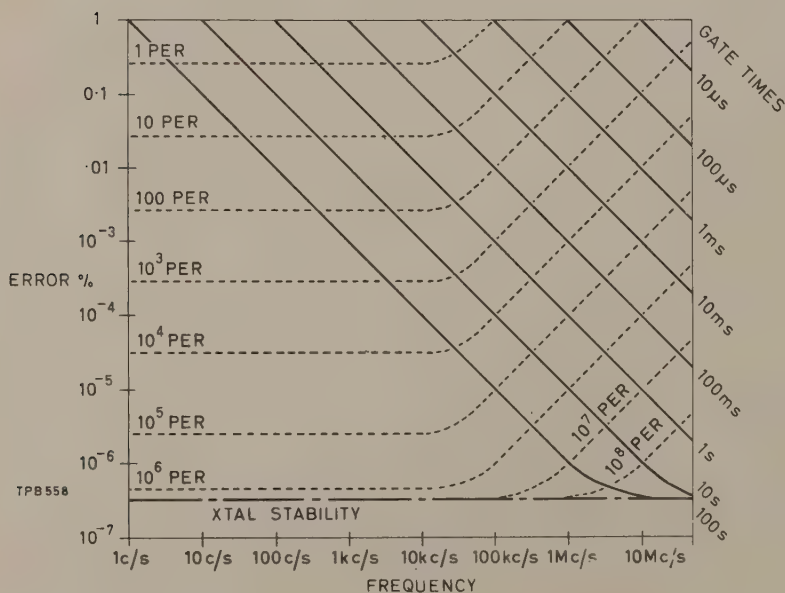
or $\frac{1}{n\pi} \cdot \frac{E_n}{E_s}$ where n is the number of periods in multi-period average measurements.

(3) Phase Measurement. The reference and out of phase signals are used to start and stop the counter, the latter being arranged for period measurement and time interval measurement.

$$\phi = 360^\circ \frac{t}{T} \quad \text{where}$$

ϕ = phase difference in degrees,
 t = phase difference in counter timing units,
 T = period of signal in counter timing units.

Thus if the counter is to read directly in degrees external timing units must be provided of a frequency $n.360 \text{ fs}$ where n is an integer determining the discrimination desired and fs is the frequency of the signal to be measured. The accuracy obtained is a function of the ambiguity of the triggering level.



ACCURACY CHART

Operation

2.1 MAINS-VOLTAGE SETTING

The instrument is normally despatched set for 230-250 V a.c. operation. A selector-plug at which voltage adjustment may be made is provided within the instrument; it is accessible after removal of the top section of the instrument case and cover-plate of the power unit type 55/210 (see diagram S65/25): the latter plate is secured by three screws.

2.1.1. Case Removal: Each section of the case is secured by one screw (6 B.A. recessed panhead) at each side of the instrument. To remove either section, withdraw the two fixing screws, slide cover backwards (sufficiently to disengage front-edge from panel surround), then raise.

Six voltage-ranges are marked on the circular selector-plug. The ranges are:-

100 - 107 V	200 - 214 V
108 - 115 V	215 - 230 V
116 - 125 V	231 - 250 V

To alter the voltage setting, withdraw the selector-plug, turn and re-insert so that upon replacement of the cover-plate the marking of the required range will be visible through the appropriate cover-plate-hole.

Replace and secure cover-plate and case before connecting mains supply.

2.2 SUPPLY CONNECTION

With voltage selector appropriately set (see Section 2.1) and with Power switch set to up (OFF) position, connect the 3-core mains cable to supply, viz:-

Red core	: mains live
Black core	: mains neutral
Green core	: earth

2.3 TEST FACILITY (1 MHz Output)

The test facility may be used to check the counting and readout operations of the instrument. To use this facility connect the '1 MHz' socket to the Signal Input socket and set the following controls as indicated.

<u>Control</u>	<u>Setting</u>
----------------	----------------

Rear:-

2-position slide switch : Internal Crystal

Front:-

a.c./d.c. switch	: a.c.
Sensitivity control	: Max.
Display Timer	: Approx. mid-setting
Memory switch	: OFF
Power switch	: ON

Below are listed the displays which should be presented (following initial counting

<u>Function Selector</u>	<u>Period Cycles/Time Units</u>	<u>Overflow</u>	<u>Display</u>		<u>Symbol</u>
<u>Setting</u>	<u>Switch Setting</u>	<u>Lamp</u>	<u>Count</u>		
Frequency 0.01 s	Any position	OFF	01.0000	1	Mc/s
Frequency 0.1 s	Any position	OFF	1.00000	1	Mc/s
Frequency 1 s	Any position	ON	000.000	1	kc/s
Frequency 10 s	Any position	ON	00000.0	1	c/s
Frequency 100 s	Any position	ON	0000.00	1	c/s
Period A x N	1	OFF	000001	1	μ s
Period A x N	10	OFF	000010	1	μ s
Period A x N	10 ²	OFF	000100	1	μ s
Period A x N	10 ³	OFF	001000	1	μ s
Period A x N	10 ⁴	OFF	010000	1	μ s
Period A x N	10 ⁵	OFF	100000	1	μ s
Period A x N	10 ⁶	ON	000000	1	μ s

periods) for each Frequency position of the Function Selector, and for each position of the Period Cycles/Time Units switch when the Function Selector is set to Period $A \times N$.

For the -1 tolerance the overflow lamp will be OFF and display will be 999999; for the +1 tolerance overflow lamp will remain ON and numeral 1 will be displayed in the least significant digit position.

Overflow and Gating lamps are situated in the left and right lower corners of the display screen respectively. The gating lamp is illuminated for the duration of each counting period.

2.4 FREQUENCY MEASUREMENT

2.4.1 Functional Description

For Frequency measurement the setting of the Function Selector determines which of five internal frequencies, derived from the reference oscillator, shall control the gate: it thus determines the gating time.

During this time, cycles of the A-input frequency are gated and thence counted by a chain of six decades. The indicators display the resultant count: this multiplied by the range factor constitutes the measured frequency.

2.4.2 Operating Procedure

(i) With the Supply switch in the ON position, set the rear-mounted slide-switch to INTERNAL CRYSTAL (if an external reference source is to be used refer to Section 2.9).

(ii) If a data logging output facility (on units with Mod. Z, Z1 or Z2) is to be utilized, refer to Section 2.10. If the auxiliary facilities (e.g. overflow output) are to be used, refer to Section 2.11.

(iii) Set the Display timer control as required.

When the control is set to INFINITY (i.e. anti-clockwise limit) reset action is initiated upon momentary depression of the Reset push-button or application of a reset input signal (for the latter, see Section 1.2.9). When the control is switched from 'INF' setting the reset action is triggered automatically, the display time is then proportional to the control rotation: the range being approx. 5 sec to 0.5 sec (Min.).

(iv) Set the Memory switch as required.

'OFF' ; For each measurement the indicators show the progression and result of each count.

'ON' : Only the result of the count is displayed; it is retained until the end of the next gating period whereupon the new count is shown. On this setting, depression of the Reset push-button (or a reset input signal) resets the counter circuit but the display remains unchanged.

N.B. The gating lamp is extinguished at the end of each gating period but no visible change will occur in the display should the new count be the same as the previous result.

(v) Connect the signal-lead to the coaxial B.N.C. socket marked 'Signal Input' and set the a.c./d.c. switch for the form of input-coupling required. If 'a.c.' is selected turn the Sensitivity control to 'MAX'.

This sensitivity setting is suitable for smooth-edged noise-free waveforms of amplitude from 100 mV to 250 V r.m.s. If interference is present, or the leading and/or trailing edges of the waveform are irregular (e.g. due to harmonic content), spurious triggering may result. A few initial measurements will show if an inconsistent reading is registered, in which case the sensitivity setting should be reduced.

For pulse inputs and frequencies above 5 MHz the Sensitivity control should be set to "Max".

(vi) Set the Function Selector to the Frequency range suitable for the measurement of the applied frequency. When the order of frequency is unknown, use the highest range (the shortest gating time: '0.01 sec') first.

(vii) Momentarily depress the Reset push-button for a measurement to be initiated. (Alternatively, a Reset signal may be applied as in Section 1.2.9 (b). (On Display control settings other than INF measurements will then occur automatically).

The resultant number displayed is the quantity of input cycles received during the gating time (as indicated by the Function Selector setting) but, where appropriate, a decimal point is illuminated and a symbol is presented so that the frequency measurement may be read directly from the display; however, any overflow must be taken into account. Whether the count capacity of the instrument will be exceeded during a measurement will depend upon the input frequency and the range employed. Whenever the count capacity is exceeded, the most significant counter resets from 9 to 0 and a Carry Signal is thereby produced (see Sections 1.2.9 and 2.11). The most-significant-digit-indicator will follow this

resetting action when the Display switch is set to 'OFF'. On setting the Memory to 'OFF' the Overflow indicator lamp (on left of display screen) is illuminated when "overflow" first occurs and remains ON until the instrument is reset.

Example: A signal of frequency 1,000,005 Hz applied with a gate time of '0.01 s' would give rise to the display 01.0000 MHz, (subject to the overall accuracy claim as stated in Section 1.2.1).

The same frequency applied with a gate time of '1 s' would cause the count capacity of the instrument to be exceeded once during the measurement period and give rise to the display 000.005 kHz with the overflow lamp on. The most significant digit (M.S.D.) '1' would not be displayed but the 7th M.S.D. '5' would be shown by the extreme right hand indicator: the overflow digit (M.S.D.) should then be added to yield the complete result 1000.005 kHz.

2.5 PERIOD MEASUREMENT

On this function a single period measurement is catered for by the position $N = '1'$ of the Period Cycles/Time Units switch, the count being recorded in 1 μ s units. Single period measurements may also be taken on the function setting 'Timing A-A' where the timing units are selectable.

2.5.1 Functional Description

With this function, the input signals control the internal gate which is held open for a duration corresponding to the number of periods of the input frequency indicated by the setting of the Period Cycles/Time Units switch (e.g. 1, 10, 10^2 etc.). Pulses derived from the reference oscillator and occurring at one microsecond intervals pass via the gate to the six decade counter chain. The resultant display is a measurement of the time for which the gate is held open and thus constitutes a Period measurement of the input waveform.

2.5.2 Operating Procedure

Carry out procedures (i) to (v), inclusive, of Section 2.4.2; then proceed as follows.

- (a) Set the Function Selector to 'Period AxN' (marked in black).
- (b) Set Period Cycles/Time Units switch to the number of periods (correspondingly marked in black) of the input over which the measurement is to be recorded (e.g. $N = 1, 10, 10^2$ etc.). The range used initially, should be selected so that the count capacity of the

instrument is not exceeded; other ranges (on which overflow may occur) can then be used to determine digits of lesser significance.

The 'Note' in Section 2.4.2 (vii) regarding overflow, is applicable also to the Period function.

- (c) Momentarily depress the Reset push-button, or apply a Reset signal, for a measurement to be initiated. On Display settings other than 'INF' measurements will then occur automatically.

- (d) The measurement is presented in micro-second units: any overflow digit/s should be taken into account in reading off the results.

Example: A signal frequency in the order of 100 Hz of period 0.01000023 seconds, applied on range '1' would give rise to a display '010000 μ s'. The same signal applied on range '10²' would produce the display '000023 μ s' with overflow of 1. The overflow digit should be appropriately added to the displayed count thereby giving the result 1000023 μ s: since this was recorded over 10^2 periods of the input waveform it should be divided by 10^2 to yield the Period measurement 10000.23 μ s. (i.e. 0.01000023 second, the original period considered).

Trigger Level Error:

Results are subject to trigger level error which is manifested in repeated measurements by jitter of the least significant digit/s. The error (for sinusoidal inputs of amplitude not less than 1 V r.m.s. and frequency not less than 100 Hz) on the various ranges is as follows.

<u>Range</u> <u>Switch</u> <u>Setting</u>	<u>Error</u>
1	Less than $\pm 0.03\%$
10	Less than $\pm 0.003\%$
10^2	Less than $\pm 0.0003\%$

etc (i.e. decreasing by a factor of ten for each successive range).

The accuracy on each range improves rapidly with increase of signal amplitude above 1 V r.m.s. and/or with a reduction of input signal rise-time. See Section 1.4, Accuracy of electronic counters.

2.6 TIMING

2.6.1 Functional Description

With this function the gate is opened and closed by externally applied signals.

During the gating time, signals from the reference oscillator pass via the gate to a frequency divider chain which supplies pulses at multiples of $1\mu\text{s}$ intervals to the counter/display circuit.

2.6.2 Operating Procedure

Carry out procedures (i) to (iv), inclusive, of Section 2.4.2 then proceed as follows.

- (a) Use Period Cycles/Time Units switch to select a timing unit suitable for the magnitude of the interval to be timed: timing units are available in decade steps from $1\mu\text{s}$ (position 1) to 1 second (position 6). Where appropriate, the decimal point is included in the readout which is presented in the unit (μs , ms or second) indicated by a red symbol against the selected switch-position.
- (b) Set the Function Selector to the required Timing position (correspondingly marked in red); the form of signals to which the instrument responds on each Timing position is treated in Section 1.2.3.

(c) Proceed according to the instructions given below against the particular Timing position selected. The remarks in Section 2.4.2 (vii) regarding overflow are applicable to all three Timing positions.

'A-A' : Carry out procedures (v) and (vii) of Section 2.4.2.

B+C pulse : (i) If the instrument is to be triggered by external signals, rather than by push-button operation, connect the input signal lines to the B (start) and C (Stop) coaxial connectors. Alternatively, the Start and Stop inputs may be linked together if single-line gate control operation is required. In such a case, two successive signals presented (after the occurrence of reset action) between the link, (i.e. centre pins of B & C sockets) and chassis-earth, will cause the gate to open and close respectively.

For each input, set the associated 'Slope' switch to the required trigger polarity (i.e. to '+' if input circuit is to be triggered by positive-going signals; to '-' for operation by negative-going signals), also set the associated B & C potentiometers for the required trigger levels (+ and - marks correspond to approximately +3 V and -3 V respectively).

The outputs of the Start-B and Stop-C input pulse shapers are available for monitoring. The exact point on

the B-input waveform at which the associated shaper is triggered, may be determined by comparison of the input waveform and Start-B shaper output when applied to the respective beams of a double beam oscilloscope: similarly for the Stop-C input. It is advisable to observe these outputs whenever there is doubt regarding the validity of displayed results.

- (ii) Momentarily depress the Reset push-button, or apply a reset signal.
- (iii) Apply a start signal to the B-input socket (or momentarily depress the Start push-button) to commence the gating time.
- (iv) Apply a stop signal to the C-input socket (or momentarily depress the Stop push-button) to end the gating time.

Should the instrument not respond to start and/or stop input signals, reduce the setting of the associated trigger level potentiometer/s and repeat the procedures (ii) to (iv) above.

B.C Contact

(i) If the measurement is to be started by operation of external contacts, rather than by push-button operation, connect a pair of normally-open contacts between the centre-pin and shell of the B-input socket. The latter contacts when closed and opened will start and stop the time interval respectively. Should it be required that a separate pair of contacts be used to terminate the time interval, similarly connect a second pair of normally-open contacts to the C-input socket.

(ii) Momentarily depress the Reset push-button, or apply a reset signal.

(iii) The time-period commences upon the closure of the B-input contacts (or upon depression of the Start push-button) and ends:-

- (1) When the B-input contacts re-open (or upon release of the Start push-button, if this is in use instead of contacts).

or

- (2) Upon closure of the C-input contacts (or upon depression of the Stop push-button): the contact

closure or push-button depression must be maintained otherwise the gate will re-open unless the B-input signal (i.e. B contact closure or B push-button depression) is first removed.

On the 'B.C Contact' function, the gating arrangement does not incorporate an inter-lock control circuit. Therefore after completion of a gating period the gate may be re-opened (by a change in condition of the appropriate contacts or push-button) without prior initiation of reset. Successive counts will in this case be cumulative. When the latter method of repeated gating is used, the Display control should be set to 'INF'; otherwise the timer (which is triggered by the first gate closure) may initiate reset action before the final count has been accumulated.

2.6.3 Connections for Contact Timing

Methods for timing the operations of contacts in various arrangements are given below. In each case the Timing function upon which the measurement may be conducted is indicated, but for precise details of procedure refer to Section 2.6.2.

(a) Closed-time of a pair of normally-open contacts:-

Use function 'Timing B.C Contact'. Connect the open-contacts between centre-pin and shell of the B input socket. Timing will commence when the contacts close and will cease when they open.

(b) Open-time of a pair of normally-closed contacts:-

Use function 'Timing B.C Contact'. Connect the closed contacts between centre-pin and shell of the C input socket. Link together the centre-pin and the shell of the B-input socket. Timing will commence when the contacts open and will cease when they close.

(c) Time between closure of a pair of normally-open contacts and closure of a second pair of normally-open contacts

Use function 'Timing B.C Contact'. The pair of contacts which upon closure is to start the timing operation should be connected between the centre-pin and the shell of the B input socket. Connect the second pair of

contacts between the centre-pin and the shell of the C input socket. Timing will commence when the first pair of contacts close and will cease upon closure of the second pair. Once closed, the first pair of contacts should remain closed; re-opening of these contacts before the operation of the second pair will end the gating period. For measurements where closure of the first set of contacts may be momentary, proceed as follows.

Use function 'Timing B-C Pulse'.

The pair of contacts which upon closure is to start the timing operation should be connected thus:-

One contact to centre-pin of B-input socket, the second contact to the Positive terminal of a battery (or similar d.c. source); the Negative battery-terminal to the shell of the B-input socket. Alternatively the Negative battery terminal may be connected, but in this case negate all references to polarity. Set the B-input Slope switch to + and the associated trigger level control to a positive level less than the battery potential. Similarly connect the second pair of contacts to the C-input socket. Timing will commence when the first pair of contacts close and will cease upon closure of the second pair.

(d) Time between closure of a pair of normally-open contacts and subsequent opening of a pair of normally-closed contacts:-

Use function 'Timing B.C Contact'.

Connect the two pairs of contacts in series between the centre-pin and shell of the B-input socket. Timing will commence when continuity is established (by closure of the normally-open contacts) and will cease when the link is broken (i.e. as the normally-closed contacts open).

(e) Time between opening of a pair of normally-closed contacts and opening of a second pair of normally-closed contacts:-

Use function 'Timing B.C Contact'.

The pair of contacts which upon opening is to start the timing operation should be connected between the centre-pin and the shell of the C-input socket, whilst the second pair should be similarly connected at the B-input socket. Timing will commence when the first pair of contacts (i.e. the C-input contacts) open and will cease when the second pair open.

(f) Time between opening of a pair of normally-closed contacts and subsequent closing of a pair of normally-open contacts:-

Use function 'Timing B.C Contact'. Connect the two pairs of contacts in parallel between the centre-pin and the shell of the C-input socket. Connect together the centre-pin and the shell of the B-input socket. Timing will commence when the normally-closed contacts open and will cease when the normally-open contacts close.

Delay between Energisation and Contact-operation of a Relay

The delay between relay energisation (or de-energisation) and the operation of the associated contacts may be determined on function 'Timing B-C Pulse'.

The external energising supply, relay-solenoid and contacts should be arranged such that upon energisation (or de-energisation) the change in voltage across the solenoid is presented as a 'gate-opening signal' between the centre-pin and shell of socket-B; whilst upon operation of the contacts a change in potential is presented as a 'gate-closing signal' between the centre-pin and shell of socket-C. The signals should conform to the specification of Section 1.2.3 (ii). Slope and trigger level controls of both inputs should be suitably set for the polarity and amplitudes of the signals (control setting is treated in Section 2.6.2).

2.7 COUNT

2.7.1 Functional Description

In this function the gate is opened and closed by external signals. During the gating time, signals received via the 'A' Signal Input socket pass to the counter/display circuit.

2.7.2 Operating Procedure

With the Supply switch in the ON position, carry out procedures (ii) to (v), inclusive, of Section 2.4.2 then proceed as follows.

- (1) Set the Function Selector to 'Count'
- (2) For gate control, proceed according to instructions given under the heading 'B C pulse' in Section 2.6.2 part (c).

Whenever the count capacity of the instrument is exceeded, the most significant digit counter resets from 9 to 0 and a Carry Signal is produced.

On setting 'Memory - OFF' the Overflow indicator lamp (on the left of display screen) is illuminated when overflow first occurs and remains ON until the instrument is reset.

2.8 TEST FREQUENCY (1 MHz) OUTPUT

Signals derived from the internal reference oscillator are available at the '1 MHz' socket irrespective of the setting of the External Reference switch; the signals are specified in Section 1.2.7: they may be used to test the instrument as described in Section 2.3.

2.9 EXTERNAL REFERENCE FACILITY

When the rear-mounted two-position slide switch is set to Internal Crystal, the adjacent input socket (coaxial) is disconnected from the main circuit and the internal oven controlled 2 MHz crystal oscillator is employed as the reference source.

When the switch is set to External Input the internal oscillator is switched out of circuit and suitable signals applied to the External Input socket serve as reference signals for the instrument.

This facility may be used to increase the accuracy of the instrument for the standard functions (i.e. by use of source frequency of accuracy better than ± 1 part in 10^7) or to alter the significance of the readout so that the instrument will operate in a non-standard manner (i.e. by use of source frequency other than 1 MHz).

The facility may be employed for frequency ratio measurement as treated in the following section.

2.9.1 Frequency Ratio Measurement

Frequency ratio measurement of signals from two sources may be conducted when the rear-mounted two-position slide switch is set to External Input. Suitable signals from one source should be applied to the External Input socket; those from the second source, to the Signal Input (A) socket.

The measurements may be conducted with the Function Selector set to one of the Frequency positions or to the Period position; the choice should depend upon the order of the ratio: the two functions will be treated separately.

Procedures (ii) to (v) of Section 2.4.2, which relate to use of the Display and Sensitivity controls, and to the normal signal-input and B.C.D. facilities, are applicable in the following functions, as are the remarks in Section 2.4.2 (vii). regarding overflow.

(a) Frequency Function

With the Function Selector set to one of the Frequency positions, signals of frequency f_1 applied to the External Input socket pass via a frequency divider chain to the

internal gate control circuit; the gate is held open while a number of pulses, equal to the division factor of the chain, is received at the External Input socket.

The division factor is dependent upon the Function Selector setting, via:-

Setting	Division Factor
Freq. 0.01s	10^4
0.1s	10^5
1s	10^6
10s	10^7
100s	10^8

During the gating period signals of frequency f_2 applied to the A-signal Input socket pass via the gate to the counter/display circuit.

The Displayed Count = $\frac{f_2}{f_1} \times$ division factor.

Example

With $f_1 = 800$ kc/s ; $f_2 = 200$ kc/s and Function Selector set to '1s' (i.e. division factor of 10^6) the displayed count would be 250000

Therefore

$$250\ 000 = \frac{f_2}{f_1} \times 10$$

The ratio $f_1 : f_2$ is therefore given by:-

$$\frac{\text{Division factor}}{\text{Count}} : 1$$

$$\text{i.e. } \frac{10^6}{250000} : 1$$

$$\text{or } 4 : 1$$

(b) Period Function

With the Function Selector set to 'Period AxN', signals of frequency f_1 applied to the External Input socket pass via the gate to the counter/display circuit.

The gate is controlled by signals of frequency f_2 applied to the A-signal Input socket. The signals pass via a frequency divider chain to the internal gate control

circuit: the gate is held open while a number of pulses, equal to the division factor of the chain, is received at the A-input socket. The division factor is indicated by the setting of the Period Cycles/Time Units switch (black figures).

The Displayed Count = $\frac{f_1}{f_2} \times$ division factor.

Example

With $f_1 = 800$ kc/s ; $f_2 = 200$ kc/s and Period/Cycles/Time Units selector set to ' 10^4 ', the displayed count would be 40000

Therefore

$$40000 = \frac{f_1}{f_2} \times 10^4$$

The ratio $f_1 : f_2$ is therefore given by:-

$$\frac{\text{Count}}{\text{Division Factor}} : 1$$

$$\text{i.e. } \frac{40000}{10^4} : 1$$

$$\text{or } 4 : 1$$

In using either method ('a' or 'b' above) for frequency ratio measurement, initial switch-settings should be chosen such that the capacity of the counter is not exceeded.

2.10. DATA LOGGING OUTPUT FACILITY
(1-2-4-8 code)

This facility is an optional extra and is provided only if initially ordered. For instruments carrying this facility a suffix is added to the instrument type number engraved on the rear panel label: the suffix is indicated below.

A rear-mounted Amphenol 36-pin socket marked 'A' is fitted for standard 4-line per digit B.C.D. output (TF 2415/1). An identical socket marked 'B' (carrying digit-outputs complementary to those of the latter socket) is fitted when 4-line per digit 'inverted' output is required (TF 2415/2).

Both output sockets are fitted when 8-line per digit output is required (TF 2415/3).

The signals are as specified in Section 1.2.9 (i); connections are as follows:-

Pin No.	Sockets A & B
1	M.S.D. '0' or '1'
2	M.S.D. '0' or '2'
3	M.S.D. '0' or '4'
4	M.S.D. '0' or '8'
5	Unused
6	2nd M.S.D. '0' or '1'
7	2nd M.S.D. '0' or '2'
8	2nd M.S.D. '0' or '4'
9	2nd M.S.D. '0' or '8'
10	Unused
11	3rd M.S.D. '0' or '1'
12	3rd M.S.D. '0' or '2'
13	3rd M.S.D. '0' or '4'
14	3rd M.S.D. '0' or '8'
15	Unused
16	4th M.S.D. '0' or '1'
17	4th M.S.D. '0' or '2'
18	4th M.S.D. '0' or '4'
19	4th M.S.D. '0' or '8'
20	Unused
21	5th M.S.D. '0' or '1'
22	5th M.S.D. '0' or '2'
23	5th M.S.D. '0' or '4'
24	5th M.S.D. '0' or '8'
25	Unused
26	L.S.D. '0' or '1'
27	L.S.D. '0' or '2'
28	L.S.D. '0' or '4'
29	L.S.D. '0' or '8'
30	Unused
31	Printer Bias Supply
32	Unused
33	Print Command O/P
34	Chassis-earth
35	Unused
36	Inhibit

N.B.

M.S.D. = Most significant digit
L.S.D. = Least significant digit

The Inhibit prevents reset action from occurring within the TF 2415 and ensures that the gate is held closed so that no change can occur in the information being printed.

It also overrides the action of the Display control circuit should the duration (i.e. Print period) exceed the Display control setting, reset is not initiated until the Inhibit signal is removed upon completion of data logging.

With the Memory 'ON' setting, once reset has occurred the gate may again be opened (to take a new measurement) but the previous information, (i.e. that just printed) remains displayed until the end of the new gating period.

The results of successive measurements may be logged at a faster rate with the Memory switch in the ON position. This is because with this setting the gate may be re-opened to start a new measurement while the previous result is still being logged (N.B. considerable increase in logging rate is obtainable when the gating time is comparable to the data logging time). For such operation

(i) The Inhibit input should not be used

(ii) The Display timer should be set so that:- Display-timer-setting plus Gating-time is greater than Data-logging-time: this ensures that gate closure (which causes the new information to pass into the store) will not occur before the previous result has been logged.

2.11 AUXILIARY CONNECTIONS

Auxiliary connections are carried by a rear-mounted Amphenol 14-pin socket and two coaxial sockets. Pin-connections at the 14-pin socket are as follows:-

Pin No.	Connection
1	Start Input
2	Reset Input
3	Divider Output (Std. Freq. Output)
4	+6 V Supply Line
5	-6 V Supply Line
6	Chassis-earth
7	Carry Pulse Output
8	Overflow Output
9	Memory Transfer
10 - 14	Unused

The two remaining connections carried by rear-mounted coaxial sockets are:

Start-B (Shaper) Output

Stop-C (Shaper) Output

'Timing B-C' and momentarily depress push-buttons Reset Zero and Start-B.

If the start input is connected to +6 V reset action is initiated and the instrument then remains in the reset condition until the connection is removed.

Minimum contact time 50 ms.

If the duration of the contact is less than 50 ms, counting may commence from other than zero since the reset transients may not have fully decayed; an incorrect result may thus occur.

Reset action (as produced by depression of Reset Zero push-button) is initiated if the Reset input is momentarily connected to chassis-earth. Minimum contact time - 20 ms.

For all functions, except $B.\overline{C}$ timing, signals received at the Start-B input pass via the associated internal pulse shaper and are produced at the Start-B (Shaper) Output. Similarly for Stop-C input signals.

The pulse shapers are not employed to control the instrument on functions Frequency, Period AxN or Timing A-A; therefore, on these functions the B and C shapers are available for use as general purpose pulse shapers.

Divider outputs 'Frequency' settings

Signals are normally available at the output but are momentarily interrupted whenever reset action is initiated: the Display Timer should therefore be set to 'INF'. The signals are not present when the Start Line is connected to +6 V.

'Timing' Settings

Signals are available at the output only while the gate is held open i.e. while timing is in progress: see Section 2.6.2. (For general purpose use, select

2.11.1 Divider Output (on functions Period and Count)

For outputs on functions Frequency and Timing, see Section 1.2.9 (c)

On function 'Period AxN' the internal frequency divider is not fed by the reference source (which feeds it on Frequency and Timing) but is fed by signals received at the A-Signal Input socket. On 'Period AxN' the divider output frequency is therefore given by:-

$$\frac{\text{A-Signal Input frequency}}{\text{Period Cycles/Time Units switch setting (black figures)}}$$

On function 'Count' the divider is unused; therefore no output signals are produced.

2.11.2 Memory Transfer

When the Memory switch is set to 'ON' and a count is in progress, the information may at any time be transferred to the store/display circuit (without affecting the progress of the count) by momentarily connecting the Memory Transfer line (Auxiliary Connections socket pin 9) to the +6 V line (pin 4). Minimum contact time: 25 μ s.

The completed count will automatically be transferred and displayed at the end of the gating period.

2.12 GENERAL NOTES

(1) Display

When the instrument is first switched ON following a long period of unuse, the glow discharge produced in some indicator tubes may not be confined to the digit or symbol required for display but may extend into other regions of the tube: the phenomenon may persist for a short period of time but will clear with use of the instrument.

CAUTION Whenever the instrument is operated with the case removed, care should be exercised to ensure that no physical contact is made with exposed connections, particularly those of the mains circuit in the regions of the Power switch and power supply unit: mains connections are also present on the copper side of the printed circuit base board.

For case removal see Section 2.1.1.

3.1 FUSES AND ADJUSTMENT OF D.C. SUPPLIES

Two preset 6 V d.c. supplies (± 6 V with respect to chassis-earth) are provided by the power unit type 55/210 (see layout diagram S65/25). These supplies may be measured at monitoring points accessible through small holes in the cover-plate of the power unit.

To check and adjust the ± 6 V supplies proceed as follows.

(i) Connect a suitable Grade 1 voltmeter (e.g. 'AVO' Model 8) between points marked 'OV' (meter Positive) and '-6 V'. The meter should indicate 6 V. If necessary adjust the potentiometer marked 'Set -6 V'; set the control as accurately as practicable for the required potential. In the absence of a supply see Section 3.1.1.

(ii) To check the +6 V supply connect the voltmeter between the points marked 'OV' (meter Negative) and '+6 V'. The Meter should indicate 6 V. If necessary adjust the potentiometer marked 'Set +6 V'; set the control as accurately as practicable for the required potential. In the absence of a supply see Section 3.1.1.

A +250 V anode-supply for the indicator tubes is also provided by the power unit, but since stabilization of this supply is not required no control or monitoring connection is fitted. In the absence of a supply (indicated by non-illumination of the display tubes) see Section 3.1.1.

If, when servicing the instrument, it is necessary to check the latter supply, it may be measured at the printed-circuit base board connections of the 12-pin power-unit-socket; these are accessible when the lower section of the case has been removed (For case removal see Section 2.1.1).

A suitable voltmeter (e.g. 'AVO' Model 8 set to 250 V d.c. range) should be connected thus:- Negative terminal to the 1st pin of the socket, Positive terminal to the 5th pin of the socket (the socket pin-connections should be counted from the end nearest to the centre of the base board. CAUTION - mains connections are present at the 10th and 11th pins). The measured potential should be $250 \text{ V} \pm 10\%$. In the absence of a supply see Section 3.1.1.

3.1.1 Fuses

Three fuses incorporated in the power unit are accessible after removal of the power unit cover-plate which is secured by three screws. In the absence of supply/s the appropriate fuse/s should be checked after switching OFF the mains input.

<u>Fuse Function and Identification</u>	<u>Rating</u>	<u>Marconi Part No.</u>
+6 V (FS1)	2 A	Z22867/5
+250 V (FS2)	100 mA	Z22867/10
Mains (FS3)	500 mA (slow blow)	Z50447

When using mains operating voltage of 100-125V, fuse FS,3 should be increased in value to 1 Amp (anti-surge).

3.2 MEASUREMENT OF INTERNAL A.C. SUPPLIES

Two alternating current supplies are provided by the power unit type 55/210, a 2 V a.c. supply used to control the temperature stabilizing circuit of the crystal oven and a 25 V a.c. supply which serves to power the oven heater-element. The supplies are not adjustable, but when servicing the instrument they may be checked at printed-circuit base board connections of the 12-pin power-unit-socket referred to in Section 3.1 above.

The supplies may be measured as indicated below.

<u>Supply between Pin Nos.</u>	<u>Voltage</u>
6 & 7	2 V a.c. $\pm 10\%$
8 & 9	25 V a.c. $\pm 10\%$

The pins should be counted from the end of the socket nearest to the centre of the instrument.

CAUTION mains connections are present at the 10th and 11th pins.

3.3 ADJUSTMENT OF PRESET OSCILLATOR TRIMMER

The output of the 2 MHz crystal controlled reference oscillator passes via a frequency divider binary to the front-panel-mounted socket marked '1MHz Output' at which it may be monitored and compared with a suitable external standard frequency.

Should the monitored frequency not conform to the specification given in Section 1.2.5 appropriate adjustment may be made to the setting of the oscillator trimmer.

Note

To allow for temperature stabilization of the oven and crystal, the instrument should be operated for at least 2 hours, preferably longer, before adjustment is made for oscillator frequency.

Removal of the top section of the case reveals a white box-like container mounted behind the Function Selector: the container houses the trimmer, crystal oscillator and oven.

To adjust the trimmer remove the black bung situated in the top of the container; insert a 6 B.A. screwdriver vertically into the exposed hole and unite with the control (approx. 1 inch or 2.5 cm below the surface).

Before checking the adjusted frequency, remove the screwdriver (to avoid the de-tuning effect of the metal tool).

For temperature stability, the bung should be replaced immediately after each adjustment of the trimmer and a period of approximately five minutes allowed to elapse before the frequency is re-checked.

3.4 REPLACEMENT OF DIGITAL INDICATORS, DECIMAL POINT LAMPS AND PLUG-IN PRINTED CIRCUIT BOARDS

The plug-in printed-circuit-boards are accessible after removal of the top section of the instrument case.

3.4.1 Digital Indicators

The digital indicator tubes are housed in 13-pin sockets mounted on the plug-in printed-circuit counter/display boards: a faulty tube may be easily replaced after withdrawal of the appropriate board.

Replacement tube: Marconi Part
No. Y50318/1

3.4.2 Decimal Point Lamps

Decimal point neon lamps are also carried by the counter/display boards and although they are soldered to pins on the boards they may be easily replaced after board removal. Each lamp occupies a grommet hole in the mounting bracket of its associated digital indicator tube; the two connections required may be noted when removing the faulty lamp or upon inspection of a similar board.

Replacement lamp: Marconi Part
No. Z50398

3.4.3 Plug-in Boards

In the event of a fault having been traced to a plug-in printed-circuit-board, it is recommended that the equipment be returned to Marconi Instruments Limited for rectification.

For each plug-in board, the finger-grip/spacers (fitted to top of board) and guide (fitted to the rear panel) are of the same colour; therefore, when boards are to be reinserted appropriate positions are readily discernible. Boards of one type bear the same colour. For board locations refer to diagram S65/25.

Extender boards for servicing all plug-in printed boards are available. A set of four: X 50999/1, X 50999/2, X 50999/3 and X 50999/4.

3.5 SYMBOL INDICATOR REPLACEMENT

With the top section of the case removed, access to the symbol indicator may be gained by the withdrawal of two or three of the adjacent plug-in boards (e.g. 55/120, 55/600, 55/100: see diagram S65/25). Sufficient space should thus be provided to allow the tube to be withdrawn and the replacement inserted in the socket.

Replacement tube: Marconi Part
No. Y50318/2

3.6 GATING AND OVERFLOW LAMP REPLACEMENT

For access to these lamps it is necessary to remove the front panel; proceed as follows.

- (i) Remove the top section of the instrument cover.
- (ii) Withdraw the plug-in printed-circuit-board type 55/610 (colour code red) situated behind the Sensitivity control.
- (iii) A metal screen is mounted between the Sensitivity control and Function Selector; disconnect the lead soldered to a tag at the lower rear corner of this screen.

(iv) Withdraw the four front-panel-fixing screws (one in each corner of the panel); then hinge forward the front panel about its lower edge.

Each lamp is held in a small clip and is connected by two leads. The termination points should be noted; the faulty lamp removed, and the replacement connected in position.

Replacement Neon Lamp: Marconi Part
No. Z50398

Re-assemble the instrument and re-connect the lead referred to in (iii) above.

3.7 ORDERING INFORMATION

When ordering spare parts quote the Marconi Instruments FPP Part Number plus the instrument Type number e.g. TF 2415 FPP/X12345/67.

Orders may be placed via a Marconi Instruments Agent or direct to

Marconi Instruments Limited,
Service Division,
Hedley Road,
St. Albans,
Hertfordshire,
England.

Replaceable parts

4.1

Circuit E66/37 (Double Decade Divider type 55/100)

Resistors

		Marconi Part No.
R1,8,9,10,17,18,25,26,34,41, 48,49,50,57,58,65,66,74	1.8 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50500/55
R2,7,42,47	470 Ω "	" /41
R3,5,12,14,20,22,29,31,43,45, 52,54,60,62,69,71	2.2 k Ω "	" /57
R4,6,13,15,21,23,30,32,44,46, 53,55,61,63,70,72	22 k Ω "	" /81
R11,16,19,24,28,33,40,51,56, 59,64,68,73,80	680 Ω "	" /45
R27,37,38,67,77,78	Unused	
R35,76	100 Ω "	" /25
R36,75	56 k Ω "	" /91
R39,79	68 k Ω "	" /93
R(81-98)	1 k Ω "	" /49

Capacitors

C1,3,5,7,9,11,21,23,25,27, 29,31	22 pF $\pm$ 10% ceramic	Y50509/2
C2,4,13,15,16,22,24,33,35, 36	47 pF $\pm$ 5% "	" /4
C6,8,10,12,17,26,28,30,32, 37	33 pF $\pm$ 5% "	" /3
C14,18,34	Unused	
C19,20	0.01 μ F $\pm$ 10% 250 V polyester	X23914/34

Transistors

VT (1-18)	U15718/1 Fairchild (2N2369)	X20638/55
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Diodes

MR(1-26),30,31,(34-39),(41-43), (45-48),(51-54),58,60,64, 65,68	1N4009 Mullard (1S44)	X20639/31
MR(27-29),32,33,40,44,49,50, (55-57),59,(61-63),66,67	Unused	

4.2

Circuit E66/38 (Low Speed Counter with Memory & Display type 55/110)ResistorsMarconi Part No.

R1,10	6.8 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50500/69
R2,6,12,16,22,26,32,36, (97-100)	1 k Ω "	" /49
R3,7	3.9 k Ω "	" /63
R4,8	4.7 k Ω $\pm$ 10%, $\frac{1}{2}$ W	X20635/12
R5,9,95	47 k Ω $\pm$ 5%, $\frac{1}{2}$ W	X50503/5
R11,14,18,20,21,24,28,30, 31,34,38,40,(79-82)	10 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50500/73
R13,17,23,27,33,37	5.6 k Ω "	" /67
R15,19,25,29,35,39	100 k Ω "	X50501/1
R41,43,45,48,49,50,52,54,57, 58,60,62,65,66,69,71,74	2.2 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50500/57
R42,47,76,77	470 Ω "	" /41
R44,46,53,55,61,63,70,72	22 k Ω "	" /81
R51,56,59,64,68,73	680 Ω "	" /45
R67,75,(83-92),94	Unused	
R93	270 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50501/11
R95	47 k Ω Electrosil TR5	X50512/2/P
R96	470 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W.	X50501/17

Capacitors

C1,3,5,7,9,11	22 pF $\pm$ 10% ceramic	Y50509/2
C2,4,(13-15)	47 pF $\pm$ 5% "	" /4
C6,8,10,12,16	33 pF $\pm$ 5% "	" /3
C17,18	0.01 F $\pm$ 10% 250 V polystyrene	X23914/34

Transistors

VT (1-10)	C407 Fairchild	X20638/69
VT (11-26)	U15718/1 Fairchild (2N2369)	" /55

Diodes

MR (1-46)	1N4009 Mullard (1S44)	X20639/31
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Indicators

V1	Decimal point neon lamp, Hivac	Z50398
V2	Numeral tube (0 to 9) GR10M/U, Hivac	Y50318/3

4.3

Circuit E66/39 (High Speed Counter with Memory & Display type 55/120)

<u>Resistors</u>		<u>Marconi Part No.</u>
R1,10	6.8 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50500/69
R2,6,12,16,22,26,32, 36,(100-102)	1 k Ω "	" /49
R3,7	3.9 k Ω "	" /63
R4,8	4.7 k Ω $\pm$ 10%, $\frac{1}{2}$ W	X20635/12
R5,9,95	47 k Ω $\pm$ 5%, $\frac{1}{2}$ W	X50503/5
R11,14,18,20,21,24,28,30, 31,34,38,40,(78-82)	10 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50500/73
R13,17,23,27,33,37	5.6 k Ω "	" /67
R15,19,25,29,35,39	100 k Ω "	X50501/1
R41,43,45,48,50,52,54, 57,58,60,62,65,66,69, 71,74	2.2 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50500/57
R42,47,76,77	470 Ω "	" /41
R44,46,53,55,61,63,70,72	22 k Ω "	" /81
R49,51,56,59,64,68,73	680 Ω "	" /45
R67,96,98	560 Ω "	" /43
R75,(83-92),94,99	Unused	
R93	270 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50500/35
R95	47 k Ω Electrosil TR5	X50512/2/P
R97	470 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	X50501/17
<u>Capacitors</u>		
C(1-5),7,9,11	22 pF $\pm$ 10% ceramic	Y50509/2
C6,8,10,12,16	33 pF $\pm$ 5% "	" /3
C13,14,15	47 pF $\pm$ 5% "	" /4
C17,18	0.01 μ F $\pm$ 10% 250 V, polystyrene	X23914/34
<u>Transistors</u>		
VT (1-10)	C407 Fairchild	X20638/69
VT (11-26)	U15718/1 Fairchild (2N2369)	" /55
<u>Diodes</u>		
MR (1-48)	1N4009 Mullard (1S44)	X20639/31
MR (49, 50)	1N4009 Mullard (1S44)	X20639/31
<u>Indicators</u>		
V1	Decimal point neon lamp, Hivac	Z50398
V2	Numeral tube (0 to 9) GR10M/U,Hivac	Y50318/3
<u>Integrated Circuit</u>		
X1	SN7400N, Texas	X50520/1

4.4

Circuit ES66/23 (Power Supply type 55/210)Resistors

		<u>Marconi Part No.</u>
R1	2.2 Ω $\pm 5\%$, 8 W	TF 2415 FPP/Y50523/1
R2	10 Ω $\pm 5\%$ Hi Stab, $\frac{1}{4}$ W	X50500/1
R3,6,8,11	470 Ω "	" /41
R4	4.7 k Ω "	" /65
R5,10	82 Ω "	" /23
R7	33 Ω "	" /3
R9	5.6 k Ω "	" /67
R12	470 k Ω "	X50501/17

Resistors Variable

RV1,2	1 k Ω Plessey	X20999/58
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Capacitors

C1,2	3000 μ F 25 V Plessey	Y20643/37
C3,6	500 μ F 25 V "	" /28
C4	8 μ F 10 V Mullard	Y50506/2
C5	1000 μ F 10 V Plessey	Y20643/33
C7	8 μ F 350 V Plessey	" /9

Diodes

MR1	1B20k05 (Rectifier) Texas	Z20648/12
MR2,3,4,7,8,9	2052 Semiconductors	X20639/32
MR5,10	BZY88/C4V7 Mullard (OAZ240)	" /33
MR6	1B15P05 (Rectifier) Texas	Z20648/11
MR11	80AS Mullard (BYX10)	X20639/35

Transistors

VT1,4	40250 R.C.A.	X20638/60
VT2	2N3053 R.C.A.	" /66
VT3,5	BSY38 Mullard	" /59

Fuses

FS1	2 A	Z22867/5
FS2	100 mA	" /6
FS3	500 mA (anti-surge) 200-250V mains	Z50447
	1 A (anti-surge) 100-125V mains	Z51384

Transformer

T1	Albion type TP223	Y50432
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4.5

Circuit E66/45 (Control, 2 MHz Oscillator & Oven type 55/502)ResistorsMarconi Part No.

R1,3	7.6 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50500/70
R2,(5-8)	10 k Ω "	" /73
R4,26	4.7 k Ω "	" /65
R9,12,14	6.8 k Ω "	" /69
R10,27	220 Ω "	" /33
R11,25	3.3 k Ω "	" /61
R13,22	2.2 k Ω "	" /57
R15	100 Ω "	" /25
R16,21,31,32	1 k Ω "	" /49
R17	33 k Ω "	" /85
R18	270 Ω "	" /35
R19,29	470 Ω "	" /41
R20,34	680 Ω "	" /45
R23	82 Ω "	" /23
R24	33 Ω "	" /13
R28	1.2 k Ω "	" /51
R30	1.8 k Ω "	" /55
R33,35	Selected on test	

Capacitors

C1,(12-14)	1000 pF $\pm$ 10% ceramic	Y50509/11
C2,3	32 μ F 10 V Mullard	Y50506/9
C4,5	0.1 μ F $\pm$ 10% 250 V, polystyrene	Y23914/27
C6	22 pF $\pm$ 10% ceramic	Y50509/2
C7	10 pF $\pm$ $\frac{1}{2}$ pF silver-mica	Y20644/14
C8	2.6 pF (trimmer)	Z50809
C(9-11)	0.01 μ F $\pm$ 10% 250 V, polystyrene	X23914/34

Transistors

VT (1-3)	BC108 Mullard	X20638/71
VT4,5	V405A Fairchild	" /65
VT (6-11)	BSY38 Mullard	" /59

Diodes

MR(1-4),6,7	IN4009 Mullard, (1S44)	X20639/41
MR5	Unused	

<u>Thermostat</u>		<u>Marconi Part No.</u>
Y1	Belling & Lee type L1450	Z50706
<u>Integrated Circuit</u>		
X1	SN7472N Texas	Z50520/4
<u>Crystal</u>		
XL1	2 MHz S.T.C. type 4444 style L	Y20650/11
<u>Socket</u>		
SKTA	Crystal socket	Z50812
<u>Thermistor</u>		
TH1	S.T.C. type M53	Y23955/2
<u>Silicon Controlled Rectifier</u>		
SCR 1	MCR 2305-2 Motorola	Z20648/13
<u>Heater Windings</u>		
H1,2	Oven heater windings	See Note
Note. The oven tube bearing windings H1 and H2 is available under Marconi Part No. Y51027		

4.6

Circuit B66/41 (Display Timer & Start & Stop Shaper type 55/600)

<u>Resistors</u>		
R1	3.9 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50500/63
R2,46,53	150 Ω "	" /29
R3,8,14,30,38,39,45,61, 64,66,70,71,73,86	15 k Ω "	" /77
R4,11,12,18,19,24,25,26 47A,48,50,51,60,63,76, 77,(82-85)	1 k Ω "	" /49
R5,28,55,68	330 Ω "	" /37
R6,22,32,35,52,69,75	3.3 k Ω "	" /61
R7,16,27,41,49,59,62,65, (78-81),90	10 k Ω "	" /73
R9	Unused	

Marconi Part No.

R10	4.7 k Ω	"	" /65
R13,15,74	6.8 k Ω	"	" /69
R17	22 k Ω	"	" /81
R20,31,34,56,72	560 Ω	"	" /43
R21,29,42	100 Ω	"	" /25
R23,44,67	220 Ω	"	" /33
R33	5.6 k Ω	"	" /67
R36	47 k Ω	"	" /89
R37	470 Ω	"	" /41
R40	100 k Ω	"	X50501/1
R43	1.8 k Ω	"	X50500/55
R47	56 k Ω	"	" /91
R54,88,89	2.2 k Ω	"	" /57
R57	270 Ω	"	" /35
R58	10 Ω	"	" /1
R87	680 Ω	"	" /45

Capacitors

C1,3	47 pF $\pm 5\%$ ceramic	TF 2415 FPP/Y50509/4
C2,4,12	1000 pF $\pm 10\%$ "	" /11
C5,10,13,15	0.1 μ F $\pm 10\%$ 250 V polystyrene	X23914/27
C6,7,9,14,16,19,20,22,23,25	22 pF $\pm 10\%$ ceramic	Y50509/2
C8,21	Unused	
C11	32 μ F 10 V Mullard	Y50506/9
C17	0.47 μ F $\pm 10\%$ 250 V, polystyrene	X23914/43
C18	0.1 μ F $\pm 10\%$ 250 V, polyester	X23914/27
C24	8 μ F 10 V Mullard	Y50506/2

Diodes

MR (1-20)	IN4009 Mullard (1S44)	X20639/31
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Transistors

VT1,3,7,8,10,13,14, 16,17,18	U15178/1 Fairchild (2N2369)	X20638/55
VT2,5,6,11,12,15,19, 20,21	V405A Fairchild	" /65
VT4	BSY95A S.T.C.	" /56
VT9	C407 Fairchild	" /69
VT22	BC108 Mullard	" /71

Integrated Circuits

X(1-6)	SN7400N Texas	X50520/1
X7	SN7410N Texas	" /2

4.7

Circuit E66/40 (Pulse Shaper & Gate type 55/610)Resistors

		Marconi Part No.
R1	68 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50500/93
R2,61,63,66,67	33 k Ω "	" /85
R3,32,34,48	470 Ω "	" /41
R4,8,9,12,17,21,52	100 Ω "	" /25
R5	1.8 k Ω "	" /55
R6,24,54	8.2 k Ω "	" /71
R7,30,41,43,59	15 k Ω "	" /77
R10	1.2 k Ω "	" /51
R11,13	2.7 k Ω "	" /59
R14,39,76	10 k Ω "	" /73
R15	4.7 k Ω "	" /65
R15A,26,37,57,60,64, 70,74,75	3.3 k Ω "	" /61
R16,19,31,79	220 Ω "	" /33
R18,20,23,36,53,56,71,80	1 k Ω "	" /49
R22	6.8 k Ω "	" /69
R25,38,40,42,(44-47),58 72,73,78	560 Ω "	" /43
R27	330 Ω "	" /37
R28,68,69	2.2 k Ω "	" /57
R29	150 Ω "	" /29
R33,35,49	1.5 k Ω "	" /53
R50	22 k Ω "	" /81
R51,55	680 Ω "	" /45
R62	27 k Ω "	" /83
R65	100 k Ω "	X50501/1
R77	150 k Ω	" /5

Resistors Variable

RV1	5.6 k Ω Plessey	X20999/55
RV2	1 k Ω "	" /58

Capacitors

C1,3,9	33 pF $\pm$ 5% ceramic	TF 2415 FPP/Y50509/3
C2,4,8	32 μ F 10 V Mullard	Y50506/9
C2A,5,7,16	1000 pF $\pm$ 10% ceramic	Y50509/11
C6	100 μ F 4 V Mullard	Y50506/5
C10,14,15	22 pF $\pm$ 10% ceramic	Y50509/2
C11,24	0.1 μ F $\pm$ 10%, 250 V, polystyrene	X23914/27
C12,13	560 pF $\pm$ 10% ceramic	Y50509/10

Marconi Part No.

C17	Unused	
C (18-23)	8 μ F 10 V Mullard	Y50506/2

Transistors

VT1,2,(4-8)	U15718/1 Fairchild (2N2369)	X20638/55
VT3,9,10	V405A Fairchild	" /65
VT (11-14)	BSY38 Mullard	" /59
VT15	C407 Fairchild	" /69

Diodes

MR1,2,(4-24)	IN4009 Mullard (1S44)	X20639/31
MR3	BZY88/C4V7 Mullard (OAZ240)	" /33

Inductors

L1,2	R.F. choke 0.1 mH	Z50524
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Integrated Circuits

X1,3,4,6	SN7410N Texas	X50520/2
X2,5,7	SN7400N Texas	" /1

4.8

Circuit E66/42 (TF 2415 Main Interconnecting Circuit)Resistors

R1,2,6,7	100 k Ω $\pm$ 5% Hi Stab, $\frac{1}{4}$ W	TF 2415 FPP/X50501/1
R3,5	390 k Ω "	" /15
R4	33 k Ω "	X50500/85
R8	10 k Ω $\pm$ 2% Hi Stab, $\frac{1}{4}$ W	X50502/25

Resistors Variable

RV1 (ganged to switch SD)	150 k Ω Plessey	X20999/56*
RV2	500 k Ω Plessey	" /51
RV3,4	1 k Ω Plessey	" /52

Capacitors

C1	0.47 μ F $\pm$ 20%, 400 V, polystyrene	X23914/24
C2(a-c)	0.1+0.005+0.005 μ F, T.C.C.	Z26102

Inductances

L1,2	Mains Choke	Z50803
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<u>Indicators</u>		<u>Marconi Part No.</u>
V1,2	Neon lamps Hivac	Z50398
V3	Symbol Indicator Tube GR71M/U, Hivac	Y50318/4
 <u>Switches</u>		
SA	Function Selector rotary	Y50405
SB	Period/Time Selector rotary	Y50406
SC	Reset Zero push-button	Z27391
SD (ganged to potentiometer RV1)	Display Timer	X20999/56*
SE	Display Slide-switch	Z27067/1
SF	'B' Slope Slide-switch	"
SG	'B' Start push-button	Z27391
SH	'C' Stop push-button	"
SI	Unused	
SJ	'C' Slope Slide-switch	Z27067/1.
SK	AC/DC Slide-switch	"
SL	Int./Ext. Ref. Slide-switch	"
SM	Power Switch	Z21090

*Potentiometer and switch are supplied under this number

Sockets

SKT(A-C), G,K,L	BNC	TF 2415 FPP/Z50319
SKT D,E	Belling & Lee type L1413	X20637/85
SKT F	Amphenol 14-pin	X20637/76
SKT H,I,J	Unused	

Data Logging Output sockets:-

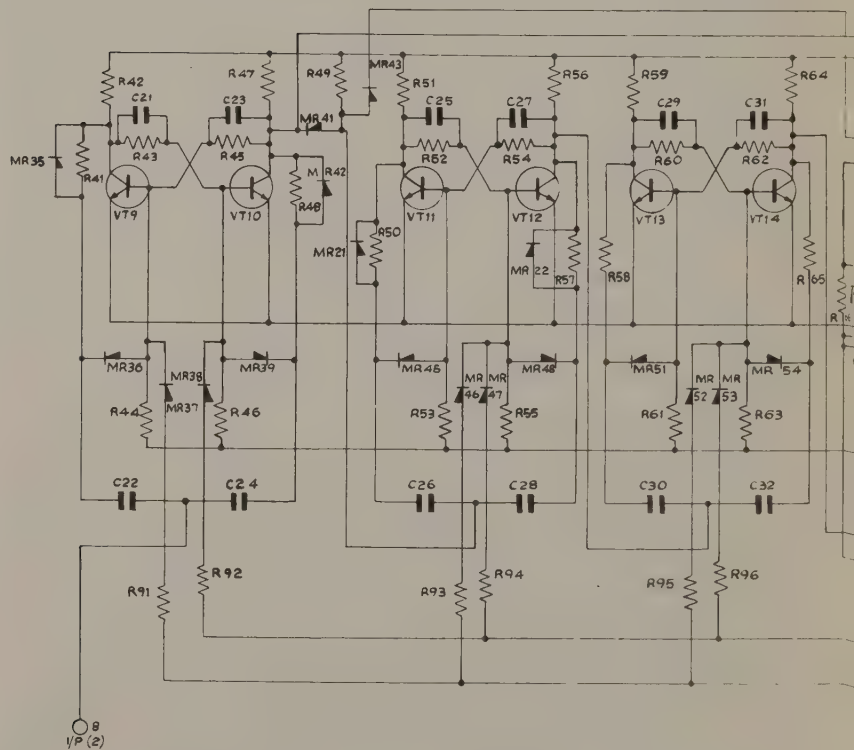
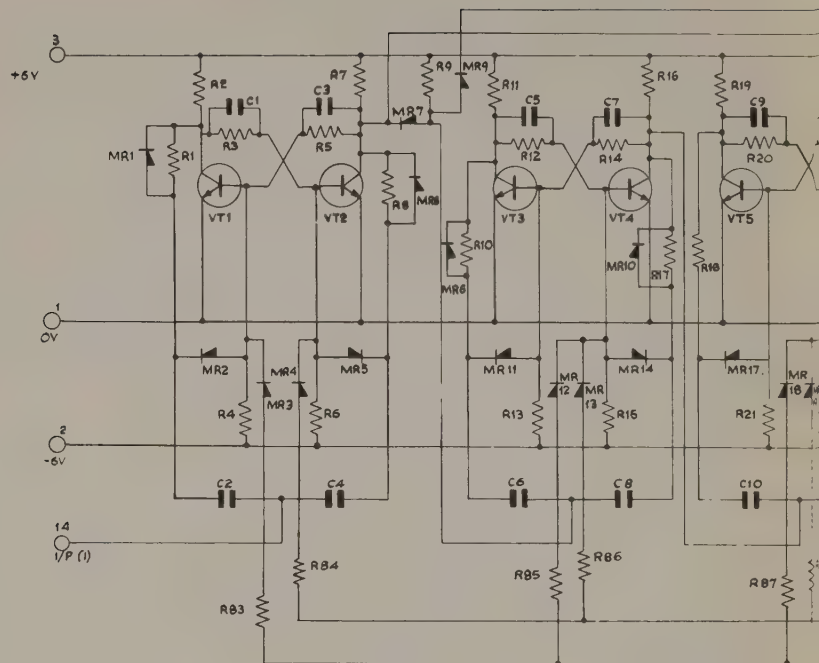
For mod. Z or Z1 one of the following type of socket is fitted

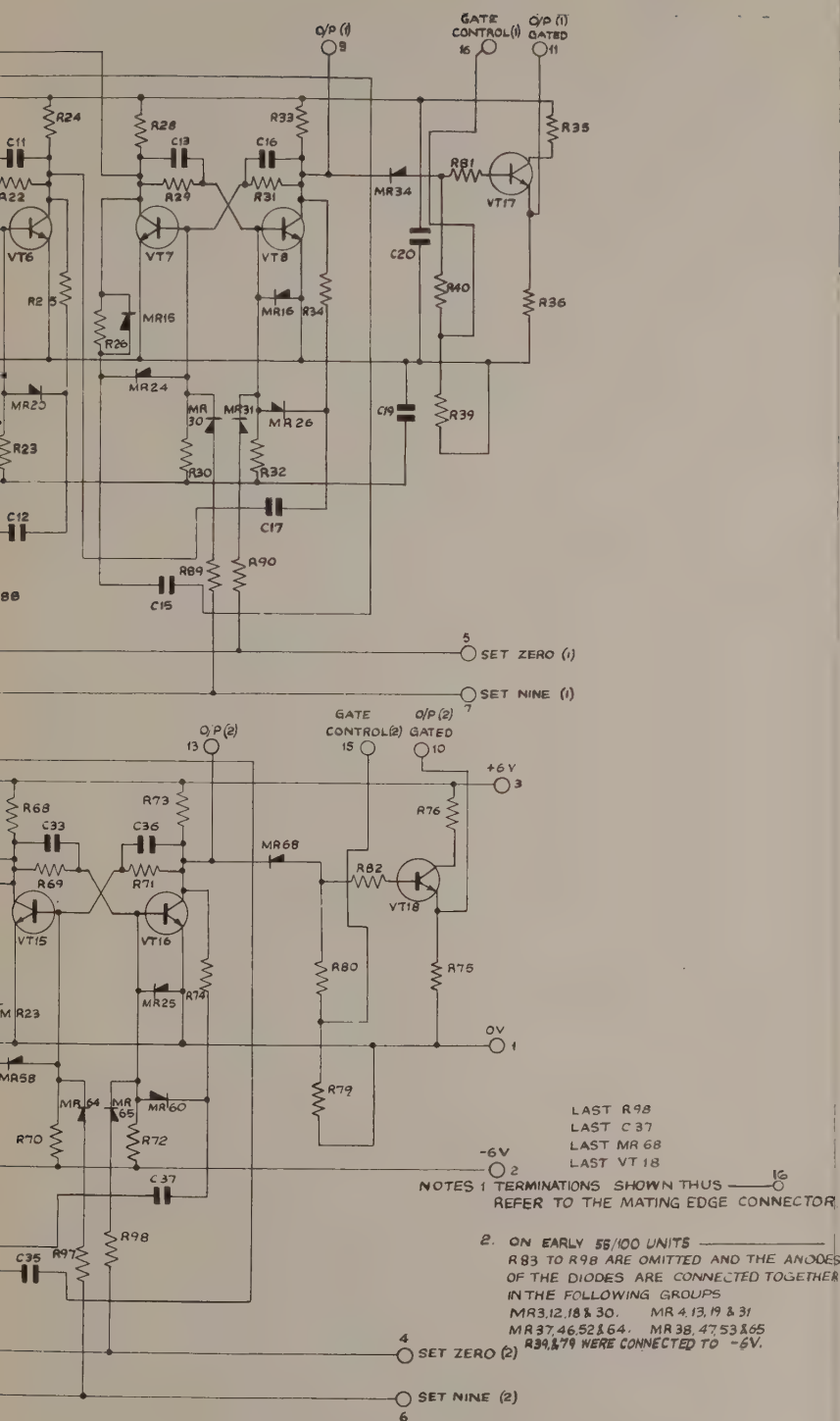
" " Z2 two " " " " " " are "

Amphenol 36-pin X20637/80

Free plugs to mate with above sockets:-

Amphenol 14-pin	X20637/75
Amphenol 36-pin	" /79
B.N.C	" /95



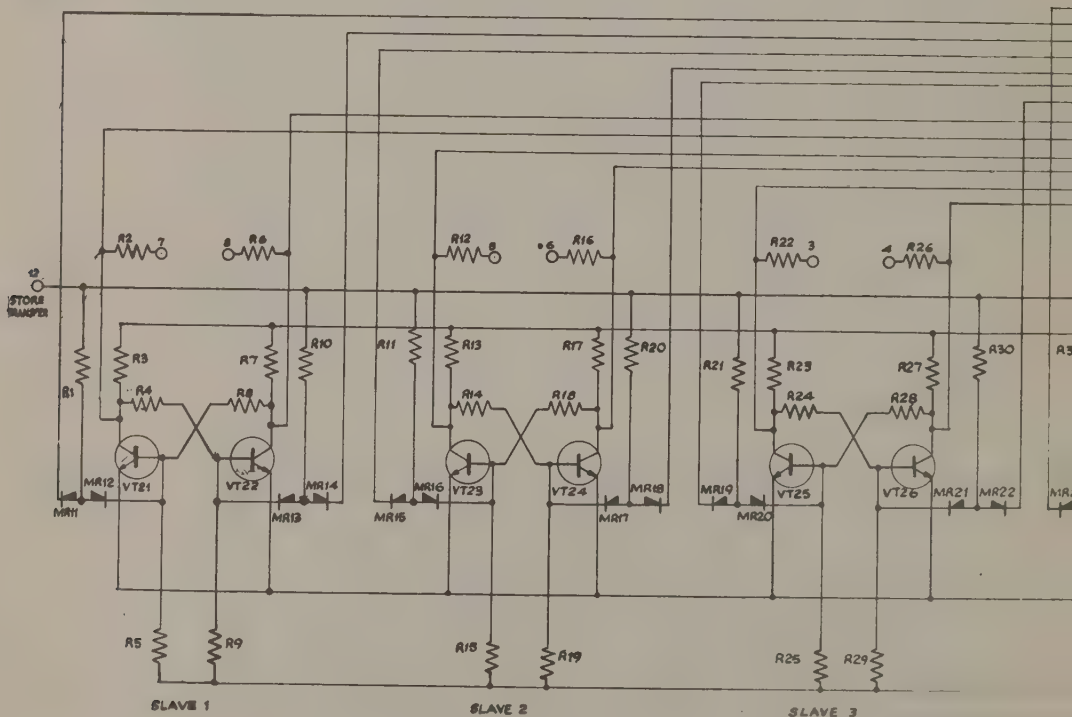
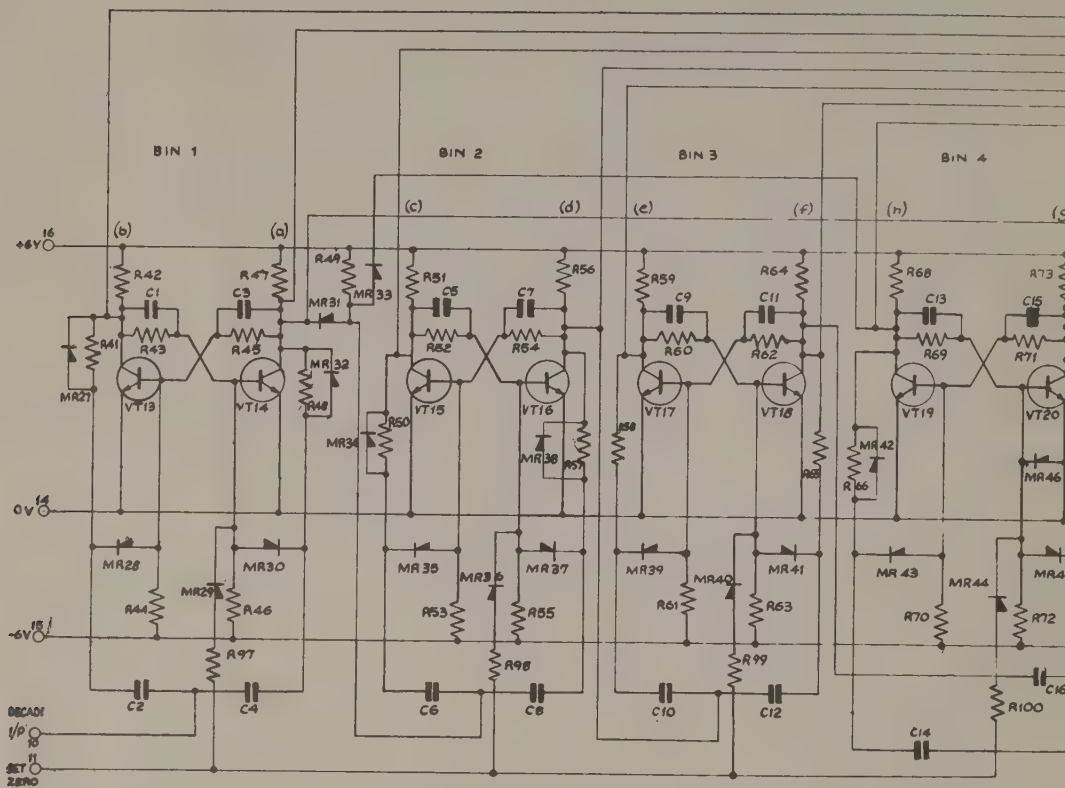


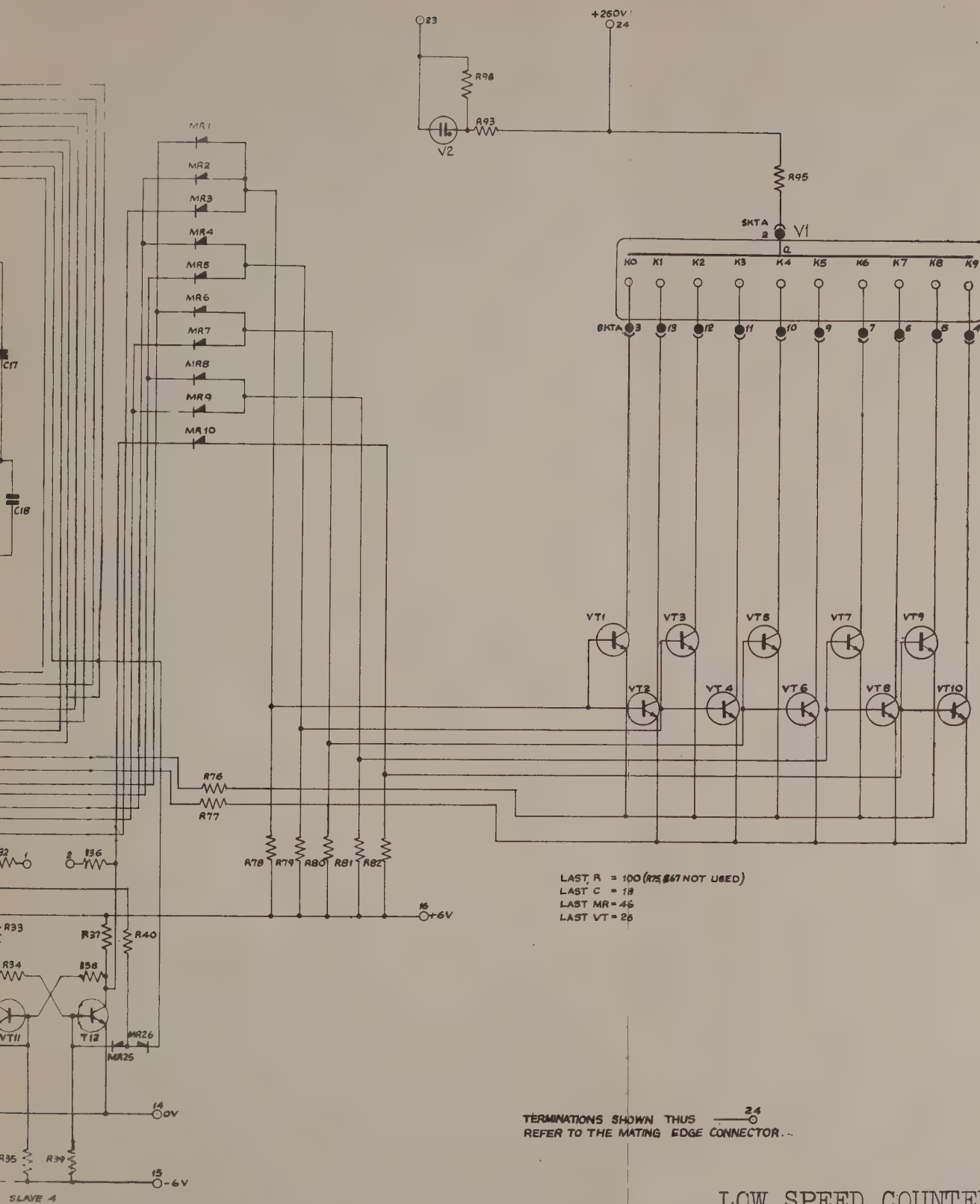
LAYOUT DIAGRAM

DOUBLE DECADE DIVIDER

E66/37

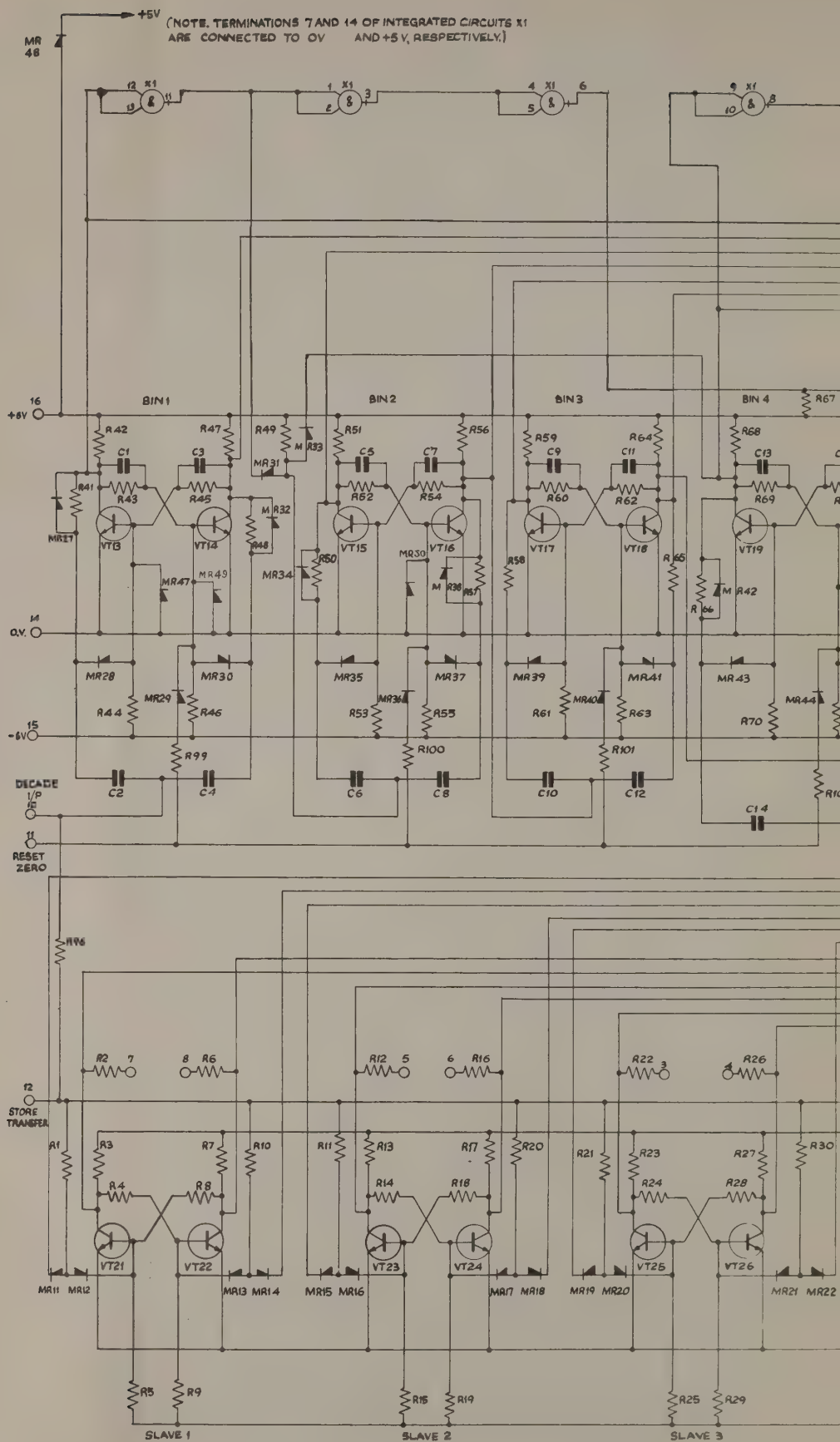
MARCONI INSTRUMENTS LIMITED TF 2415

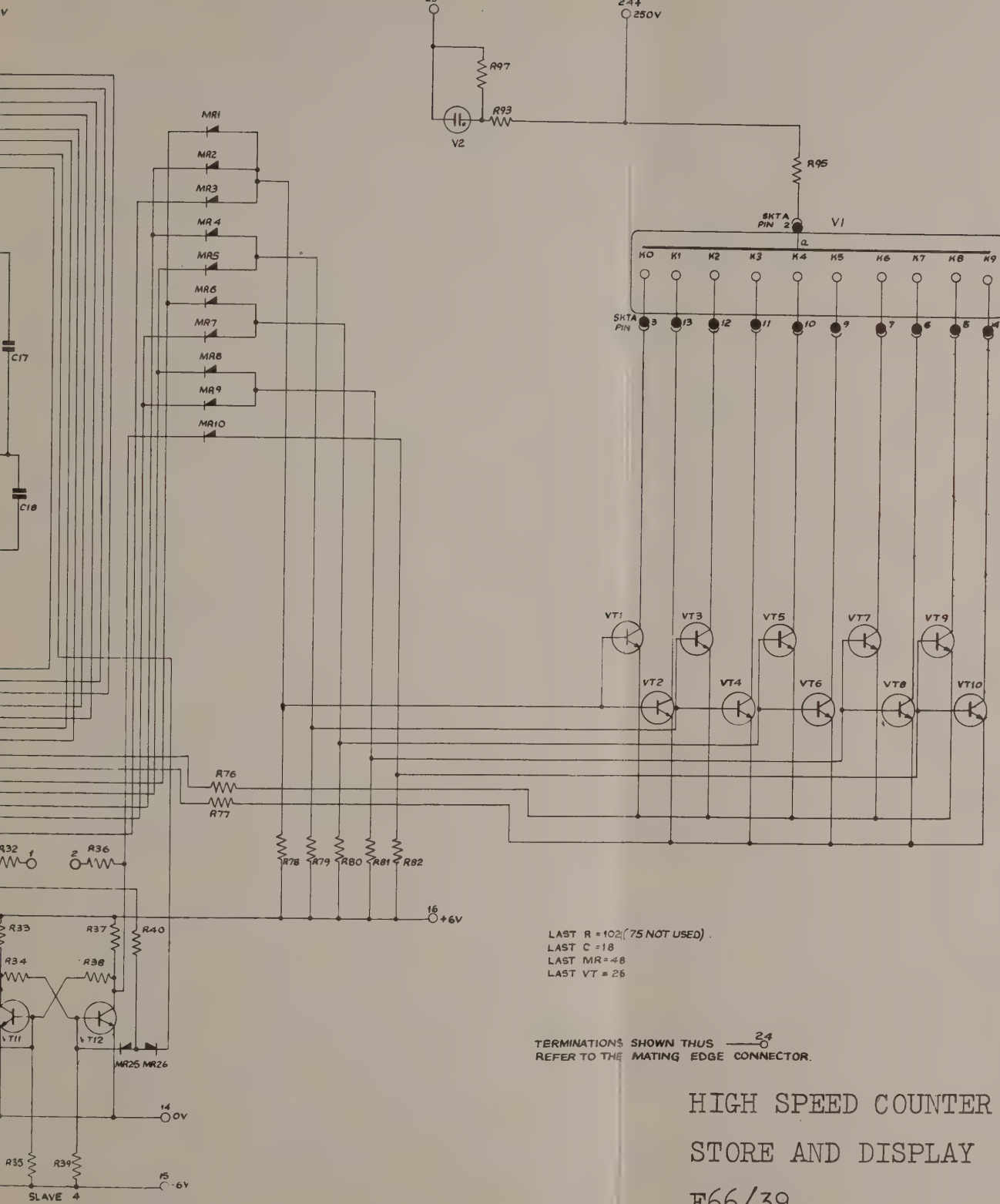




LOW SPEED COUNTER WITH STORE AND DISPLAY

E66/38

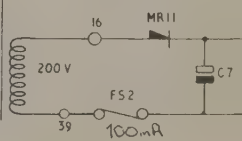
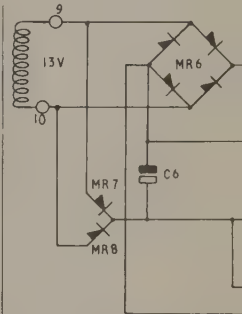
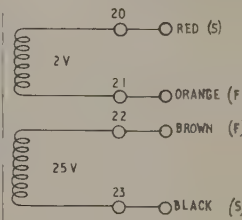
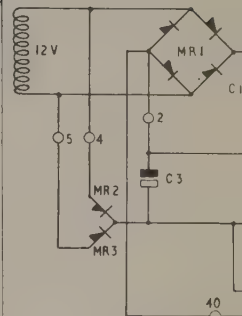
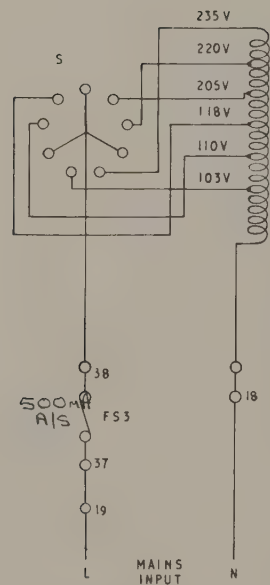


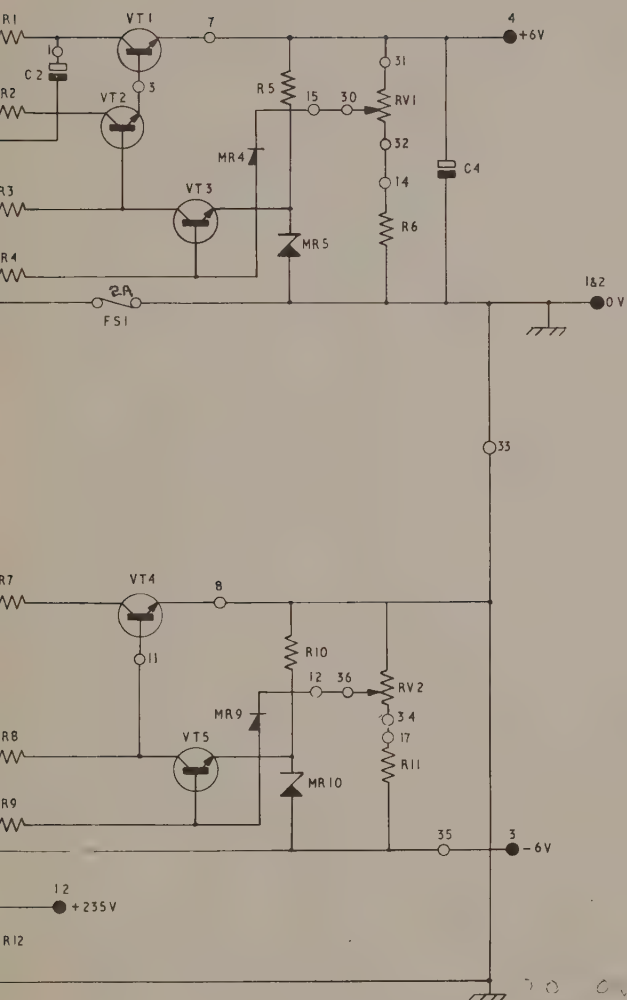


LAST R = 102 (75 NOT USED) .
 LAST C = 18
 LAST MR = 48
 LAST VT = 26

TERMINATIONS SHOWN THUS  REFER TO THE MATING EDGE CONNECTOR.

HIGH SPEED COUNTER WITH
 STORE AND DISPLAY
 E66/39

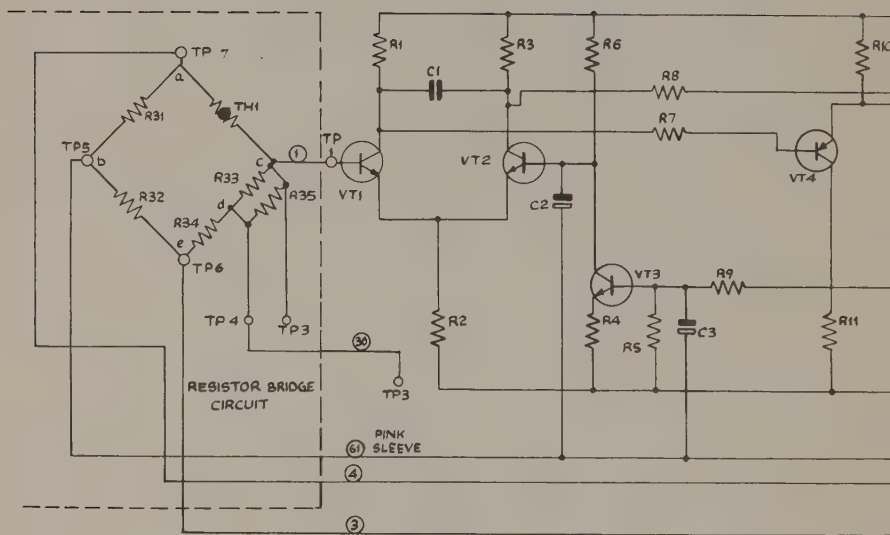




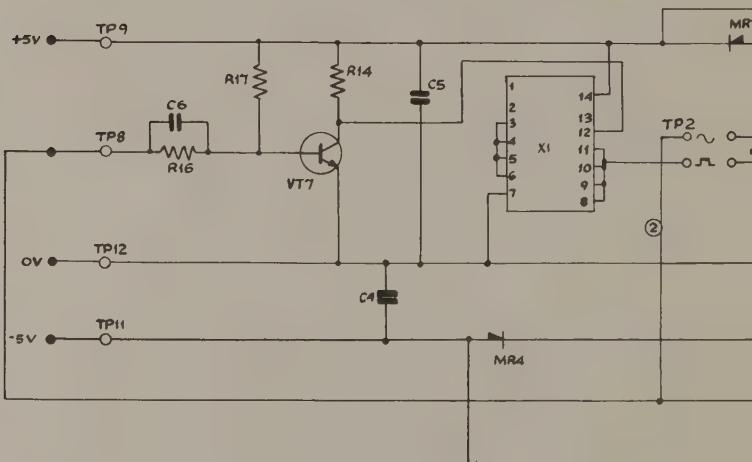
TERMINATIONS SHOWN THUS — 4 REFER TO THE MATING EDGE
CONNECTOR CONTACTS.
TERMINATIONS SHOWN THUS — 7 REFER TO BOARD PIN NOS.

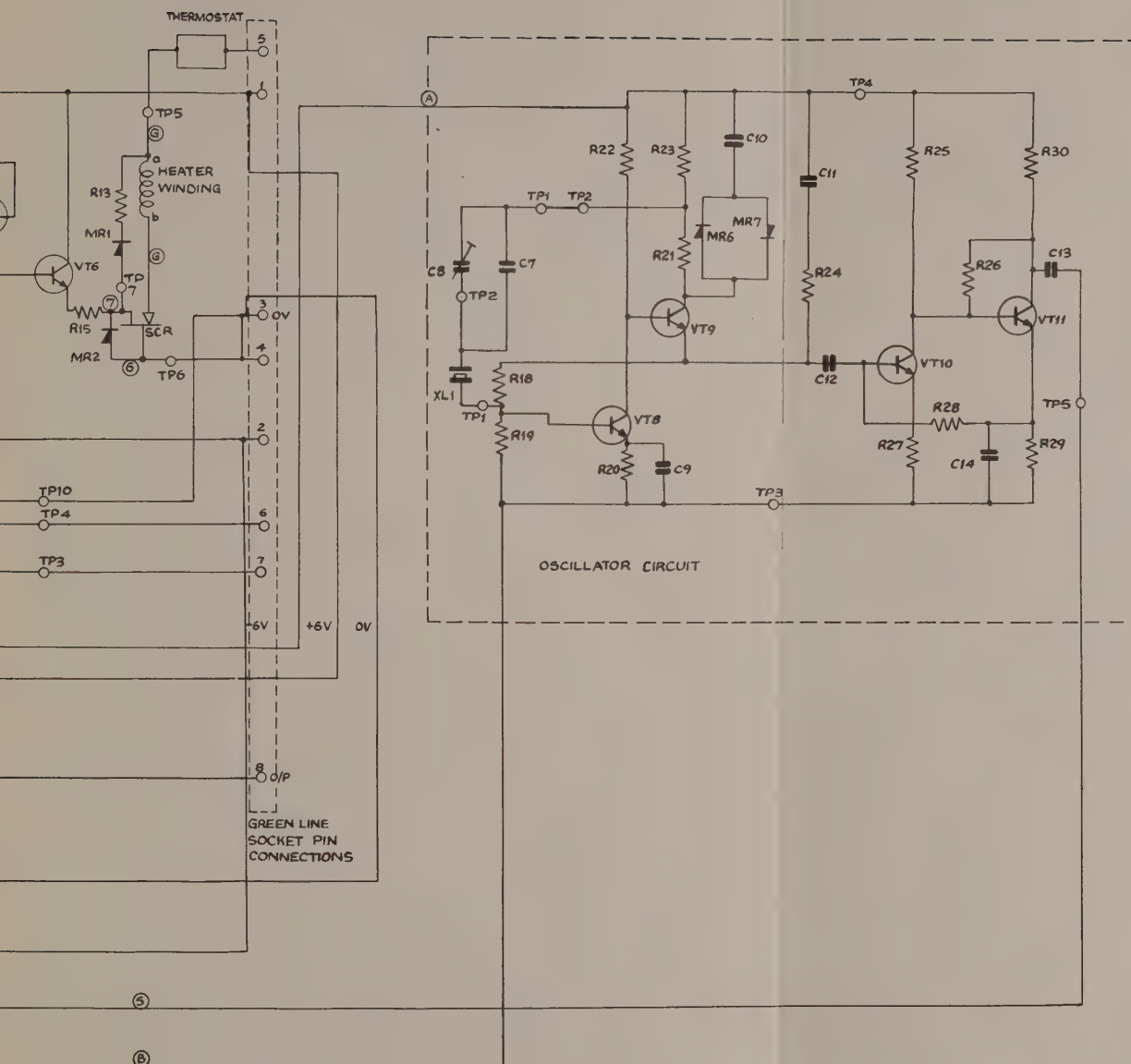
POWER SUPPLY CIRCUIT
ES66/23

MARCONI INSTRUMENTS LIMITED TF 2415

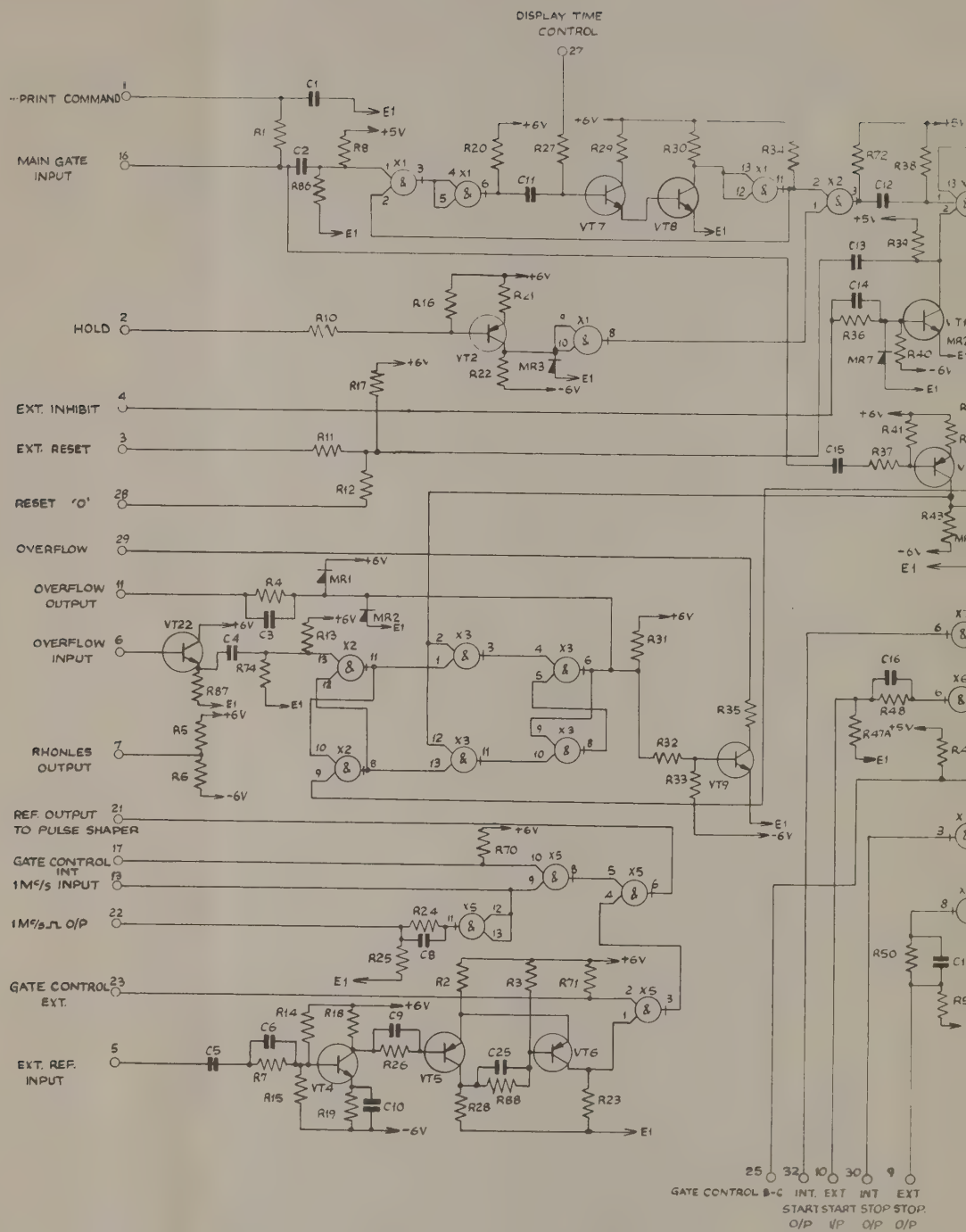


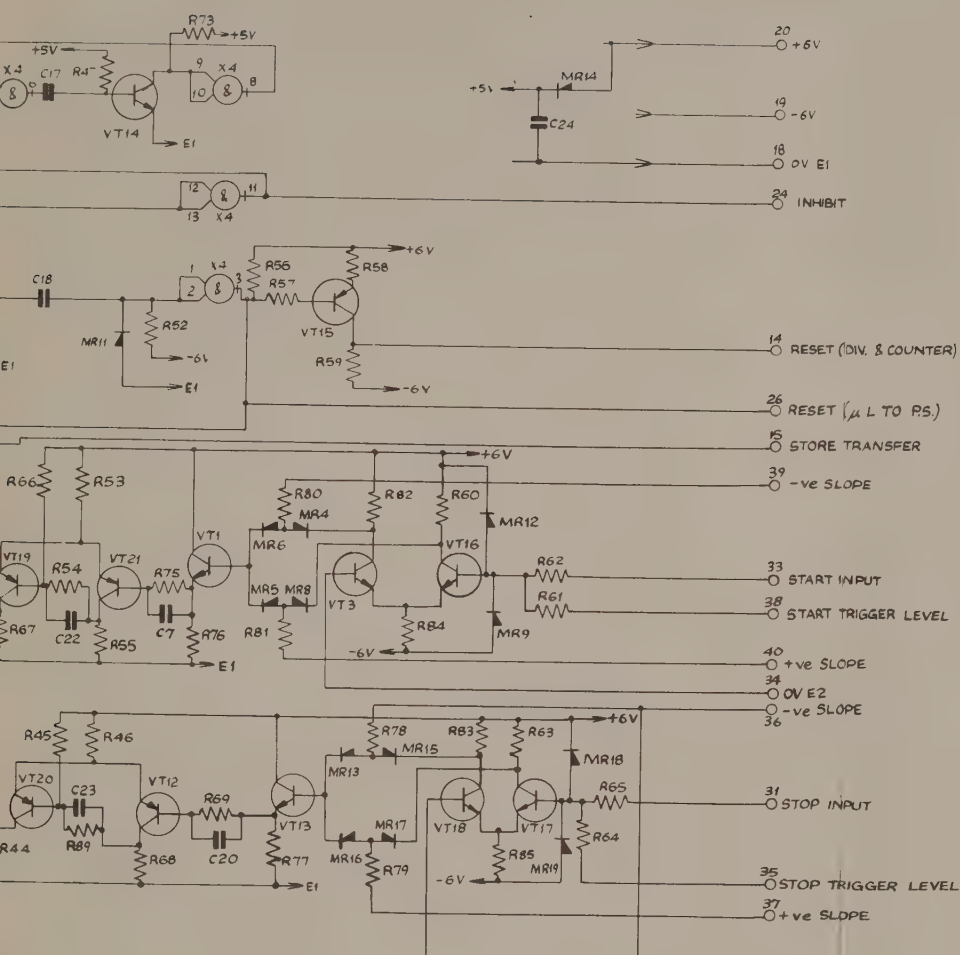
CONTROL CIRCUIT





CONTROL AND OSCILLATOR
CIRCUITS, FOR THE OVEN
E66/45





NOTES

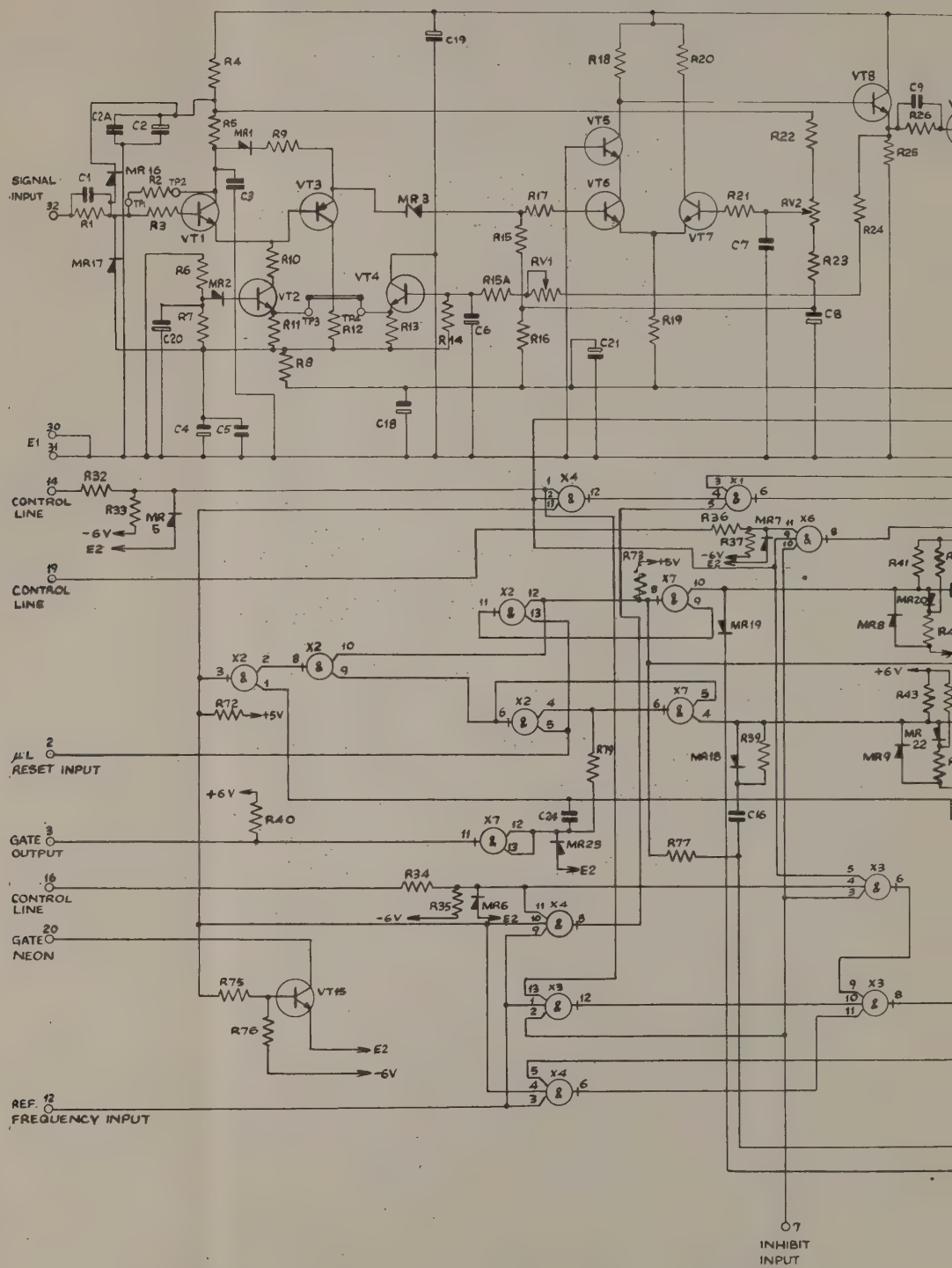
1. TERMINATIONS 7 AND 14 OF INTEGRATE CIRCUITS X1-X7 ARE CONNECTED TO 0V (E1) ARE +5V RESPECTIVELY
2. TERMINATIONS SHOW THUS $\frac{24}{\circ}$ REFER TO THE MATING EDGE CONNECTOR

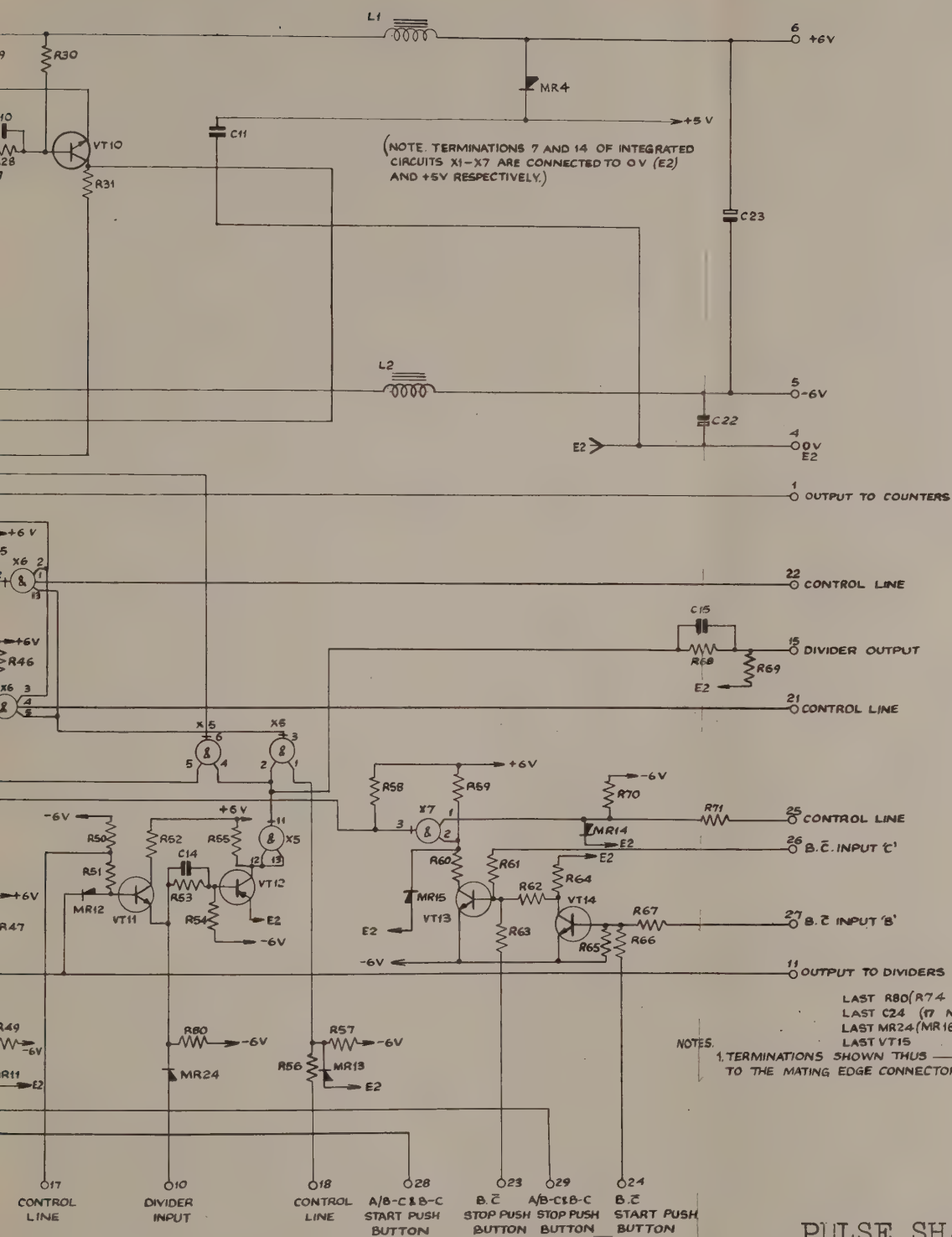
LAST R = 90 (89, 9 NOT USED)
 LAST C = 25 (21, NOT USED)
 LAST MR = 20
 LAST VT = 22

DISPLAY TIMER & START STOP SHAPER

E66/41

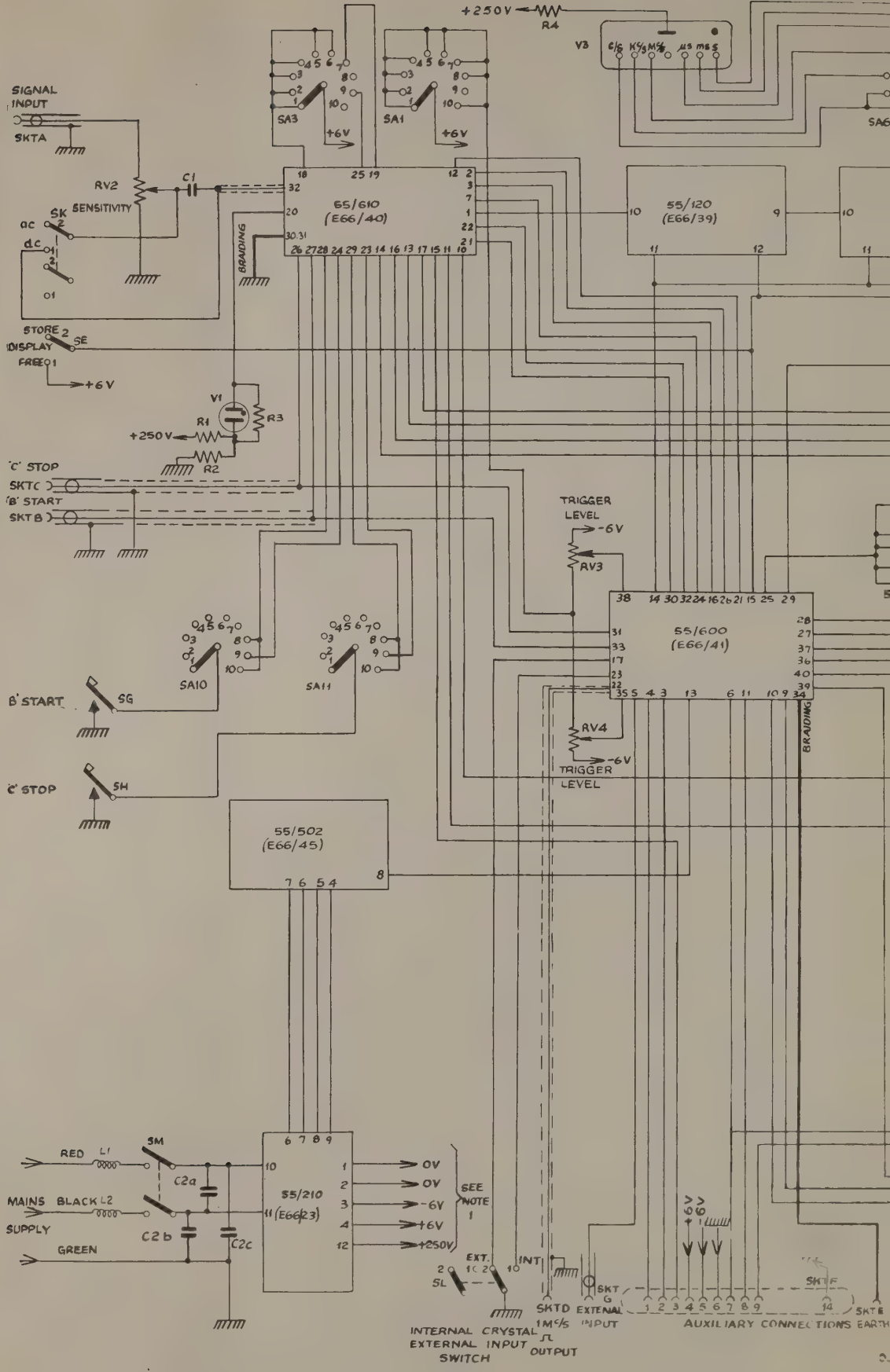
MARCONI INSTRUMENTS LIMITED TF 2415

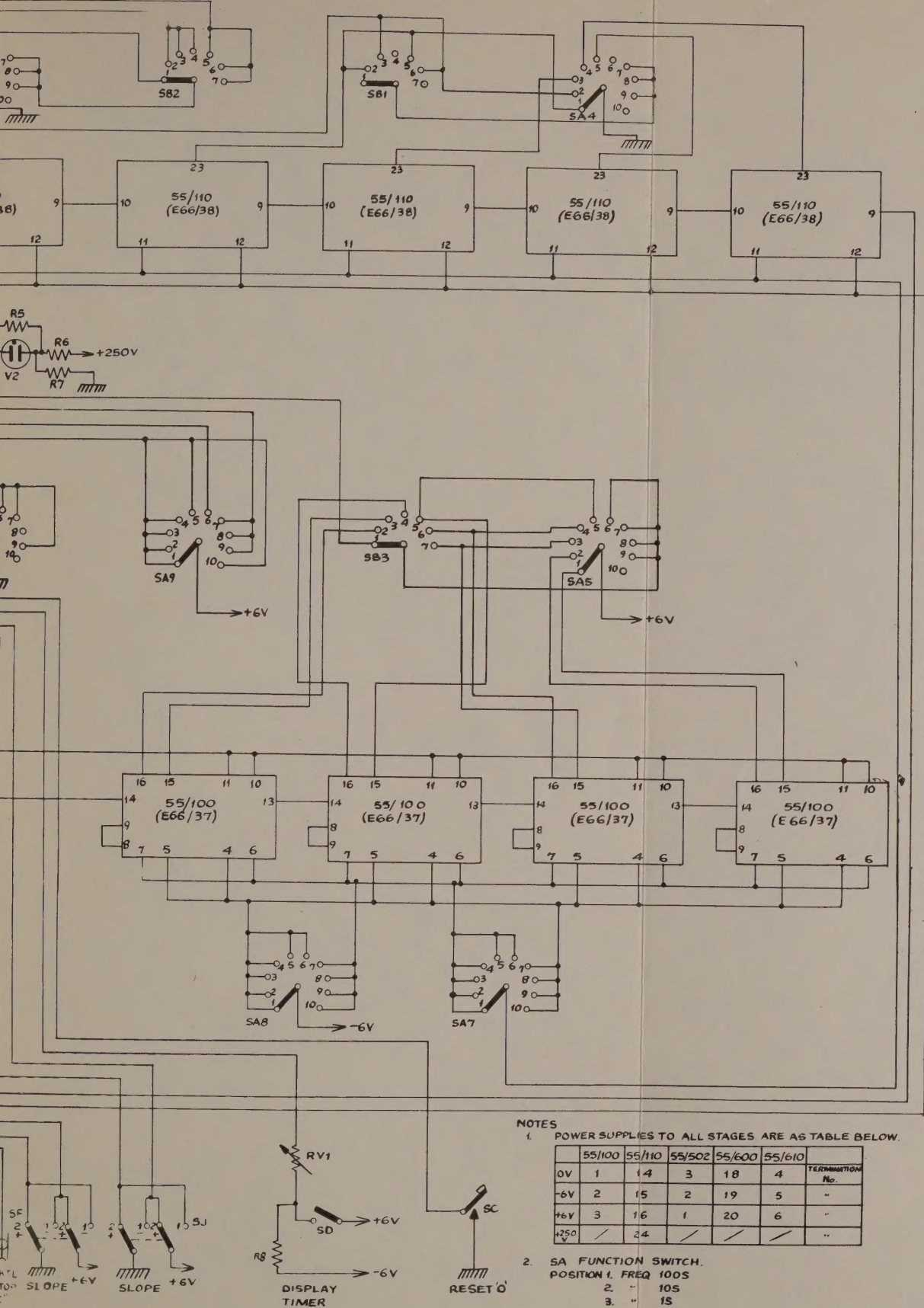




PULSE SHAPER & GATE

E66/40





DIGITAL COUNTER

E66/42

MARCONI INSTRUMENTS LIMITED

TF 2415

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ST. ALBANS, HERTS., ENGLAND**

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DEUTSCHLAND**

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Fernschreiber: 05/24642*

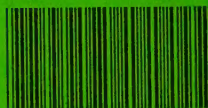
FRANCE

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WORLD-WIDE REPRESENTATION

MP MASTER



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